**IOT-based Lithium Ion Battery Monitoring Management System in Electrical Vehicle**

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**Abstract.** Li-ion batteries are the main unit of electric vehicles, but their safe and efficient operation gives us much easier monitoring systems. This paper gives about the IoT trends in Battery system management, moving beyond simple techniques. The paper aims to show case how IoT technology is changing the Li-ion battery management system in which it is safer, more reliable and more efficient in EV. We'll also touch upon future research directions, highlighting the potential for further innovation in this rapidly evolving field. We'll examine IoT integration that allows for real-time data collection from individual battery cells, which enables precise tracking of their health and performance. By using cloud-based analytics, we can process large amounts of data and large patterns and predict potential issues before they become serious. This proactive approach is important for ensuring the safety and longevity of these vital energy storage units.

**Keywords**: IoT, Electric Vehicle, battery management system, cloud-based analytics.

**INTRODUCTION**

Li-air batteries, due to their concentration, output, and lengthy life, have become the dominant technology for Electric Vehicles [1]. In recent years, the advancement of EVs has highlighted extended driving ranges and efficient delivery, making them the ultimate choice for electrical vehicle cars [2]. Electrical vehicle car sales and affect have seen significant growth, driven by advancements in Li-air batteries technology, attractive electrical vehicle car performance, government encouragement, and it’s push to reduce greenhouse gas emissions [3]. Li-air batteries are right now the most suitable option for powering an electrical vehicle car, but their maximum energy density is still lacking to meet the demands of extended-range electrical vehicle car [4]. EVs in conclusion, the batteries have contributed in the development of EVs, and ongoing research is focused on improving their performance and exploring new battery technologies [5]. The future of EV batteries involves advancements in manufacturing processes, materials and designs, as well as addressing challenges related to sustainability, cost and stability [6]. As the EV market is getting bigger, cell development will be very crucial in driving transportation that is good for the environment.

Lithium can be used in batteries to power the EV or the HEV. AI has revolutionized battery diagnostics the battery management system (BMS) is solely responsible [7]. It performs critical functions such as state cell balancing to maintain battery safety and reliability, monitoring and evaluation, and charge control [8]. Interestingly, the role of BMS has evolved to a system consisting of more than one component. Advanced BMSs now incorporate features like simulation, thermal management, and fault diagnosis [9]. Providing crucial data about information about battery parameters like V and I dynamics of each cell [10]. Platforms integrate data acquisition and wireless communication modules into battery modules in large-scale lithium-ion battery systems, and cloud-based battery condition monitoring platforms using IoT devices have been created [11]. Cloud components such as storage, analytics software, and visualization support precise monitoring of the individual cell health conditions with high-performance computing resources; these provide inter-module communication and cloud connectivity [12].

Efficiency is highly valued considering available power and battery constraints for small IoT devices [13]. IoT research and standards have been focusing on energy-saving problems of devices, and techniques such as "think before you talk" and "race to sleep" are essential to improve battery life of distant IoT devices, which is essential to prevent maintenance cost as well as environmental effect in radio tech such as equipment type comms, (IEEE 802.11ah), Bluetooth Low Energy, and Z-Wave [14]. IoT technology has remained at the epicenter of amplified battery safety, reliability, and peak performance in a broad category of applications including utility-scale energy storage and portable devices [15]. IoT technology has further revolutionized the monitoring of batteries to encompass collecting, analyzing, and managing data in real time. With the expansion of the market a few of the fields of future trend research can be more energy efficiency and implementation of next-generation technologies such as machine learning and artificial intelligence to enhance battery performance and reliability to its utmost level.

**PROBLEM STATEMENT**

Heat generation is the main issue with Lithium-ion batteries. The batteries generate heat from chemical reactions among the elements within the battery and the internal resistance of the battery during both charging and discharging phases. Keeping track of internal resistance is crucial for reviewing a battery’s internal energy usage. Warming of the battery causes protruding, formation of parks, and harms the entire application, and in extreme situations, the battery might explode. This leads to battery ageing and thermal runaways.

Although various kinds of cooling systems are advanced, they demand significant expenses and upkeep. The air cooling system requires high costs for large volumes and exhibits low efficiency in cooling.

**OBJECTIVES**

The main aim of this is to suggest designs that will identify battery faults before there occur and prevent battery overheating. IoT helps in recognizing the issue and then communication occurs. The goals are

•  Battery performance testing.

•  Testing battery capabilities under nature conditions.

•  Monitor and measure cell heating status using Info of Technology.

•  System of coolant for the cell.

**SYSTEM DESCRIPTION**

The block diagram consists of a Li-Ion battery, an LM35 Temperature sensor, an ADC, voltage and current sensors, a power supply, Aurdino UNO R3 microcontroller, a relay, an IoT module, and an LCD. The block diagram of the battery monitoring and management system is shown in Figure 1. The system's flow chart is shown in Figure 2.

A diagram of a computer program

AI-generated content may be incorrect.

**FIGURE 1.** Cell managing block diagram.

A diagram of a battery

AI-generated content may be incorrect.

**FIGURE 2.** Parameter flow graph.

The calculate battery parameters like voltage flowing in the actuator is obtained. These are interfaced with Proteus, a program simulation interface. Actuators monitor the battery's heat content in real-time. This technique is cost-effective and efficient, and the analog output of sensors is converted. The ampere output is monitored by the available sensor and prevents battery from being overloaded. When we sense the overload, the transfer separates resultant value, the change in voltage is sensed through sensors by a actuator, and battery is regularly seen status of battery is displayed through Crystalline Display. The components used is given in Table 1.

**TABLE 1.** Components.

|  |  |  |
| --- | --- | --- |
| **Sl. No.** | **Components** | **Specification** |
| 1. | Microcontroller | UNO R3 |
| 2. | LCD | normal |
| 3. | LM35 | 4-6 V,1-2Ah |
| 4. | Relay | 10-12 V,6 Ah-7Ah |
| 5. | Diode | IN4007 |
| 6. | Capacitor | 24-26 V, 1µF |
| 7. | 7805 comp | 4-6 V,1-2Ah |
| 8. | Pump | 11-13V,2-3Ah |
| 9. | Li-ion cell | 3.55 V, 2.5-3 kMAh |
| 10. | ACS712 | * 1. V,1-2 Ah |

Aurdiuno uno R3 board is used to connect and designing the embedded systems. Smaller posterior components enhance the response and stability of the system. Amp-limited resistors are used to regulate current flow to an LED.

**BATTERY MONITORING AND MANAGEMENT**

### **Voltage measurement**

Battery voltage checking is done to verify if cells are functioning correctly for higher life duration. The voltage operating range for Li-ion batteries lies between 2 V to 4.5 V which are capable of identifying AC or DC voltage levels.

### **Current measurement**

The BMS tracks current to avoid overcharging. The ACS712 current sensor can measure and monitor the current flowing to the battery. The ACS712 is a widely utilised current sensor to operate on Hall Effect. The present sensor tracks the output and protects against overheating. The relay shuts separate the O/p if overload is sensed. Thus, the voltage and current sensors regulate the status of the cell.

**Temperature measurement**

The temperature changes the chemical reactions occurring within the battery. Cold temperatures also affect cell security efficiency.  The interior oppositional force of a battery and its temperature related in an opposite correlation we can measure the Celsius we need LM35 sensor Its operational range is -55 degrees to 150 degrees Celsius. Monitoring is very essential and that is why we have set up our IoT device in that manner.

### **Battery management – Cooling system**

A suitable strategy is crucial for decreasing power losses in the system. The creation of a cooling system necessitates the adoption of control. The cooling placed between possesses a denser and better capacity holder of high temperature making efficient at releasing high temperatures, and can provide greater benefits due to its amazing the heat dissipation. The system is going to decrease necessity of using multiple fans, unlike an air cooling system. The closed water loop cools silently, noise becomes an issue here. We can use the value obtained to assess heat, type result surpasses that gets produced within the battery and, in doing so, releases it.

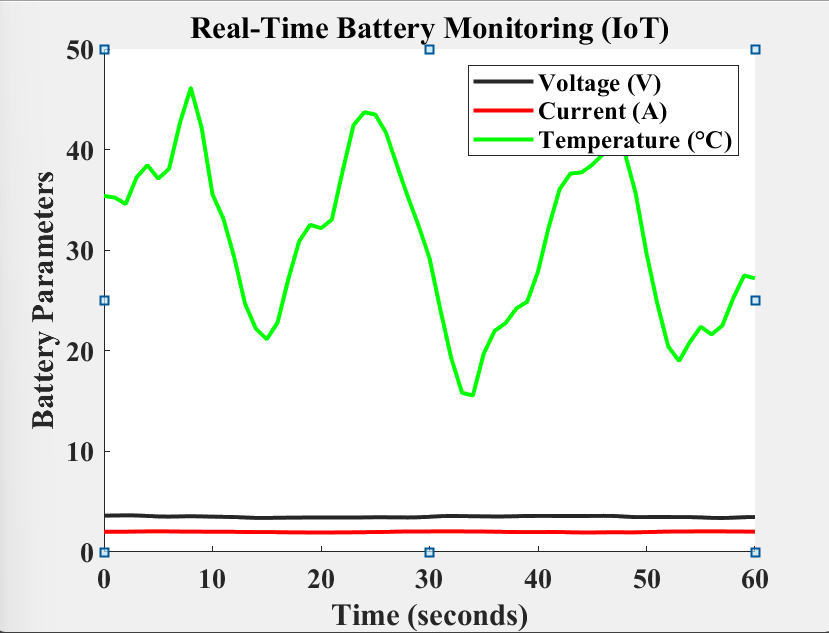
**SIMULATION RESULT**

We were able to simulate the system using the software Proteus, which will link the prototype to the IoT module when activated and then real-time values will be displayed consisting of volt ampere and heat flow status. When the values go ahead or behind the specifications an abnormal message will be shown on the Liquid Crystal Display. Status of the voltage, current and temperature is listed in Table 2.

**TABLE 2.** Status of the voltage, current and temperature.

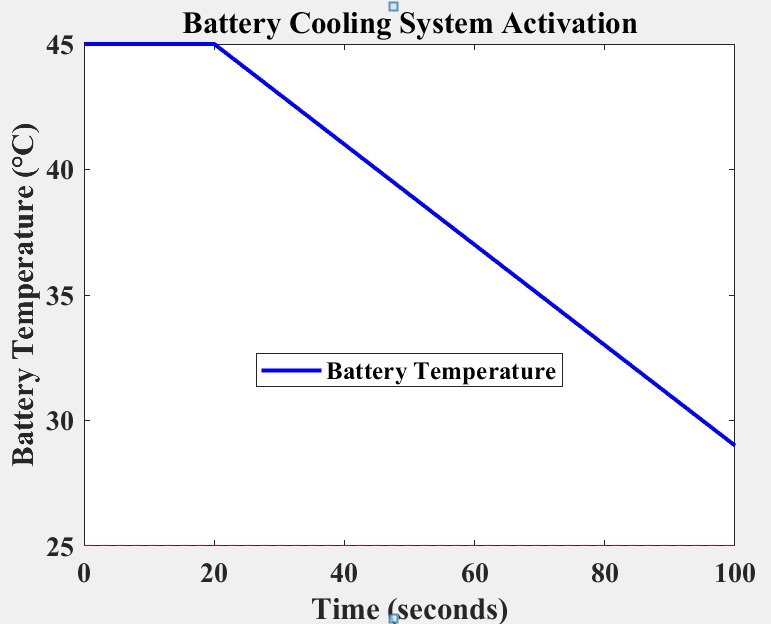
|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Parameters** | **Range** | **Message displayed on LCD** |
| 1. | Volt | <2.5V | Abnormal |
| 2-5V | standard |
| >4.2V | Abnormal |
| 2. | Ampere | <= to 2-2.5A | Normal |
| >2A | Not standard |
| 3. | Temperature | < 10 \* Celsius | Abnormal |
| Ten degrees Celsius – Sixty degrees Celsius | Normal |
| >Sixty degrees Celsius | Abnormal |

The **real-time battery monitoring waveforms shown in Figure 3** illustrate voltage, current, and temperature change over time as the battery works. Voltage remains safe between 2.4 V to 4.2 V, where the battery is neither charged nor overcharged. The current flows in different limits where it’s safety limits 2A. The temperature varies according to the usage of the battery. This graph gives us the performance of the battery continuously.



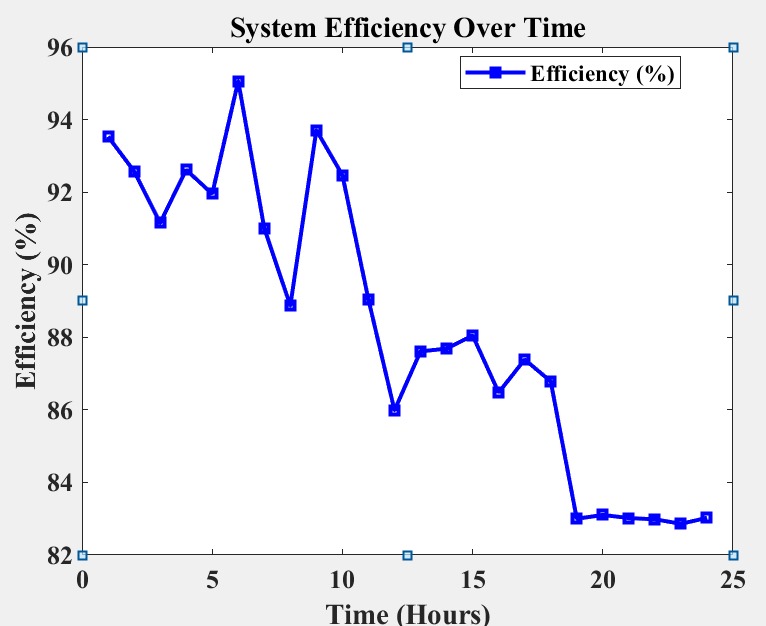
**FIGURE 3.** The Real time battery monitoring voltage, current, and temperature waveforms.

Figure 4 demonstrates the battery's temperature waveform. This activation **reduces the temperature over time**. Without an effective cooling system, excessive heat can **reduce battery performance and increase safety risks**. This gives better battery performance.

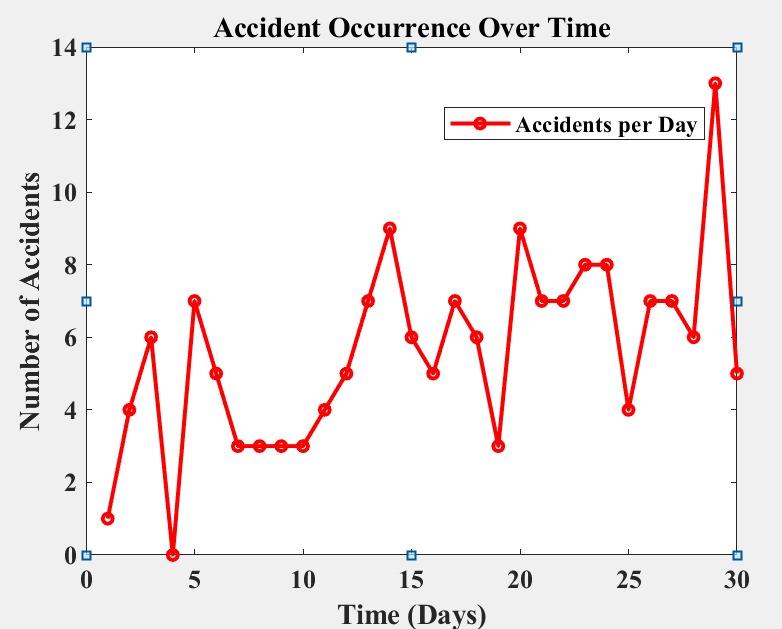


**FIGURE 4.** Battery's temperature waveform.

The efficiency with respect to time is illustrated in Figure 5. The battery efficiency graphs show how the battery’s life reduces when it ages. For every 100 days, it reduces by 5%. It affects the whole system’s performance.



## **FIGURE 5.** The efficiency with respect to time is illustrated.



**FIGURE 6.** The accident occurrence over time waveform.

The Accident occurrence over time waveform is illustrated in Figure 6. It gives us the data of abnormal condition of the system such as overcurrent, overvoltage and overheat. This can predict the fault before it occurs, which increases the safety mechanism. This system makes use of a Peripheral Interface Controller to check and manage the cell parameters. This system locates it through mechanism of liquid cooling. The system is to assess and track the battery's heat flow, amperes and volt values with a detector that consistently checks these parameters, while also notifying the user’s phone device via IoT tech. If the microcontroller senses an increase in temperature, then only is the cooling system engaged to decrease the cell temperature and avoid any further damage. This suggests that the system design improves the battery quality to be optimal. Here, a liquid cooling system is shown due to its highly abled cooling efficiency and dependability. This liquid cooling system based on IoT will improve the performing efficiency for the battery.

## **CONCLUSION**

This paper presents a design for device, utilizing a Peripheral Interface Controller, which is a microcontroller. We can then show control of the parameters Li-ionised suggested is made so as to expose important aspects of the battery that regularly monitor these parameters during usage and, thus, send alert message to user’s smart device.

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