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# IoT Based Electrical Vehicle Battery Management System with Charge Monitoring and Fire Protection

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**Abstract:** The IoT-based Electrical Vehicle Battery and Fire Protection Management System work focuses on developing a comprehensive safety and monitoring system for Electric Vehicle (EV) batteries. Utilizing a microcontroller, the system integrates various sensors and continuously monitor the health and performance of the EV battery. Key components include a voltage sensor for tracking battery voltage levels, and a DS18B20 temperature sensor to monitor the battery temperature. A Battery Management System (BMS) is a critical component in electric vehicles (EVs) and other battery powered systems. It monitors and controls the operation of the battery pack, ensuring its optimal performance, safety, and longevity. Cooling equipment is also integrated to help cool the battery when temperatures rise above safe levels. A buzzer provides an audible alert for the user in case of any critical conditions. Using latest wireless technologies, sensor data will be sent to the IOT platforms like ThingSpeak application. The system displays real-time data on an LCD screen, offering an interface for monitoring battery conditions. By ensuring timely detection of critical issues such as overheating, this system enhances the safety and reliability of electric vehicle batteries, preventing potential fire hazards and maximizing the battery's lifespan.

**Keywords**: Battery Management System, IOT, Raspberry Pi, Temperature sensor, Voltage sensor.

## 1. Introduction And Background

Current electric vehicle battery management techniques frequently rely on stand-alone sensors [1]. To notify users of anomalous situations, these systems may have visual indications or basic alarms. They usually do not have the ability to transmit data in real time [2]. Further, these systems frequently lack integration with remote monitoring platforms [3]. The rapid advancement of electric vehicles (EVs) has underscored the need for efficient battery management systems (BMS) that not only optimize performance but also prioritize safety [4]. With the incorporation of user-friendly displays and notifications, this innovative approach not only enhances the longevity and reliability of EV batteries but also ensures a safe ride [5].

The present work "IoT-Based Electrical Vehicle Battery Management System with Charge Monitoring and Fire Protection" addresses these critical needs by integrating various sensors to monitor essential battery parameters, including load, voltage, and temperature. This system employs real-time data transmission to the cloud for remote monitoring while facilitating immediate responses to hazardous conditions, such as overheating.

An Electric Vehicle typically catches fire because of excessive heating. The electric vehicle's battery warms up, and when that heat interacts with the battery internals, it simply catches fire. We need battery management system (BMS) that controls and keeps track of the operation of rechargeable batteries, such as those found in renewable energy sources and electric cars. By keeping track of the battery's state of charge and overall health, and guarding the battery from harm brought on by overcharging or overheating, the BMS aids in ensuring the safe and effective operation of the battery. One of the key functions of a BMS is to prevent the battery from being overcharged or over heated, which can cause permanent damage to the battery and reduce its lifespan. Another important function of a BMS is to ensure that the battery is operating within a safe temperature range. Overall, a BMS is an essential part of any rechargeable battery system since it ensures the battery's safe and effective operation and increases its longevity.

## 2. Literature Survey

This work intends to improve battery management in electric vehicles (EVs) by incorporating Smart Internet of Things (IoT) technologies. Because of the

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growing popularity of electric vehicles, there is an urgent need for solutions to enhance range, battery lifespan, and environmental effect. The primary source of electricity in EV's is batteries. Lithium-ion battery is extensively employed for energy storage in EV. BMS will monitor the parameters and determine battery state of health and maintains the system in accurate, reliable state and also determines the life span of a battery.

M. H. Rehman et al. employ IoT technologies to demonstrate a real-time battery management system. In addition to sending the same data online via an IoT-based Wi-Fi module, the device may flash real-time parameters on an LCD. The system is small, simple to create, and incredibly economical [6]. The system is capable of monitoring the real time values of crucial parameters and sending the data to an IoT platform. This design of an optimized thermal management system for Li-ion batteries has challenges because of their stringent operating temperature limit and thermal runaway, which may lead to an explosion.

The main approach is to devise the necessary components that can control the thermal instability of batteries, also called the Battery thermal management system (BMS) [7]. For Li-ion batteries a BMS is an essentially required sub-system while being operated under high surrounding temperatures. The BMS controls the battery temperature rise to stop the occurrence of a thermal runaway leading to safe operation and improved cycle life of the battery.

A battery management system is necessary for the reasons listed below: 1. Preserve the battery's reliability and safety. 2. Monitoring and evaluating the battery voltage. 3. To regulate the charge condition. 4. To regulate the temperature. 5. Regenerative energy operation [8]. The previous battery monitoring system merely used an internal battery indicator to alert the user and track and identify the battery's state. Users can now receive battery status through advancements in IOT system design [9]. IoT makes use of internet connectivity in ways that go beyond traditional applications, enabling a wide variety of gadgets and commonplace items to be connected online and putting the entire world at the user's fingertips [10].

**Raspberry Pi 4 Model B**

Raspberry Pi 4 Model B features a high-performance 64-bit quad-core processor, dual-display support at resolutions up to 4K via a pair of micro-HDMI ports, hardware video decodes at up to 4Kp60, up to 8GB of RAM, dual-band 2.4/5.0 GHz wireless LAN, Bluetooth 5.0, Gigabit Ethernet, USB 3.0, and PoE capability (via a separate PoE HAT add-on). For the end user, Raspberry Pi 4 Model B provides desktop performance comparable to entry-level x86 PC systems.

**Figure. 1** Raspberry Pi

This product retains backwards compatibility with the prior-generation Raspberry Pi 3 Model B+ and has similar power consumption, while offering substantial increases in processor speed, multimedia performance, memory, and connectivity.

**ARDUINO**

ARDUINO UNO is a microcontroller board developed by Arduino.cc which is an open-source electronics platform mainly based on AVR microcontroller Atmega328. The current version of Arduino Uno comes with USB interface, 6 analog input pins, 14 I/O digital ports that are used to connect with external electronic circuits. Out of 14 I/O ports, 6 pins can be used for PWM output. It allows the designers to control and sense the external electronic devices in the real world.

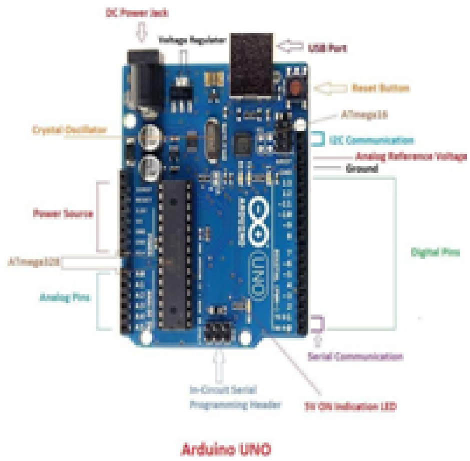


**Figure. 2** Ardino UN0

**Voltage Sensor**

This sensor is used to monitor, calculate and determine the voltage supply. This sensor can determine the AC or DC voltage level. The input of this sensor can be the voltage whereas the output is the switches, analog voltage signal, a current signal, an audible signal, etc. The measurement of these sensors can depend on the voltage divider.

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**Figure. 3** Voltage Sensor

**DS18B20 Temperature Sensor**

The digital temperature sensor like DS18B20 follows single wire protocol and it can be used to measure temperature in the range of -67oF to +257oF or -55oC to +125oC with +-5% accuracy.

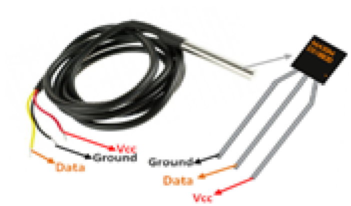


**Figure. 4** Temperature Sensor

**LCD Screen**

LCD (Liquid Crystal Display) is a type of flat panel display which uses liquid crystals in its primary form of operation. LEDs have a large and varying set of use cases for consumers and businesses, as they can be commonly found in smartphones, televisions, computer monitors and instrument panels.

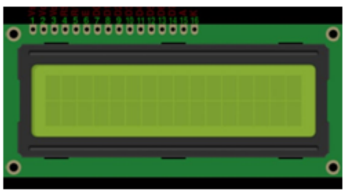

**Figure. 5** LCD Display

**Buzzer**

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Buzzer is an integrated structure of electronic transducers, DC power supply.Active buzzer 5V Rated power can be directly connected to a continuous sound.

**Fig 6: Buzzer**

**CPU Fan**

A CPU fan, also known as a heatsink fan or cooler fan, is an essential component in a computer's cooling system. Its primary function is to dissipate heat generated by the central processing unit (CPU) during operation. Without proper cooling, the CPU can overheat, leading to reduced performance, instability, or even permanent damage.

**Figure. 7** CPU Fan

**Relay**

A relay is an electromagnetic switch that is used to turn on and turn off a circuit by a low power signal. Most of the high-end industrial application devices have relays for their effective working. Relays are simple switches which are operated both electrically and mechanically.

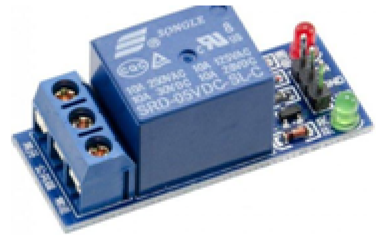

**Fig 8: Relay**

**Software Description**

To make software to work with embedded systems it is important to bring software and hardware together. For this, burn our source code into microprocessor or microcontroller which is a hardware component and which takes care of all operations to be done by embedded system according to code. Generally, source codes are written for embedded systems in assembly language, but the processors run only executable files. But for Arduino code is written in Arduino IDE and push the code into the Arduino board by selecting the right board and port. In the case of Raspberry Pi, Python programming language is used for coding in IDLE and run through the provided shell/terminal. The output can be seen in the terminal and the same can be seen through LCD screen. The Pi transfers the sensor data from its terminal to IOT platform named ThingSpeak for remote monitoring of the Battery Management System.

## 3. Implementation

The working of the system is as follows:

**Monitoring:** The system continuously tracks key parameters like voltage, temperature. The Arduino collects the raw data of voltage from the voltage sensor, Raspberry Pi takes the raw values of temperature and Raspberry Pi micro controller collects both values of voltage and temperature and sends the

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data to the micro-controller i.e., Raspberry Pi.

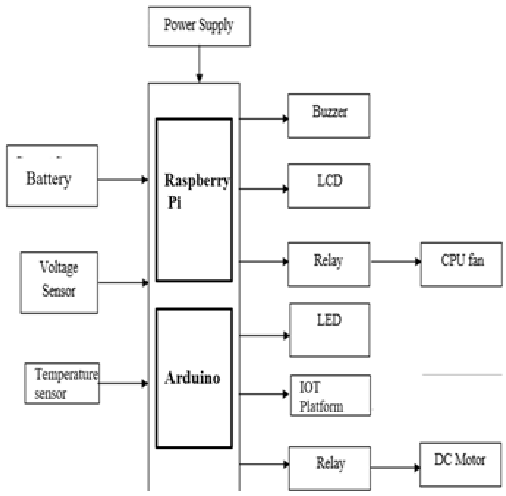


**Figure. 9** Block Diagram

**Display:** The system remotely displays the voltage fluctuations and temperature changes. The values are displayed on the IDLE shell and LCD screen for real time monitoring.

**Protection:** Safeguards the battery pack from over-discharge, over-temperature, and short circuits. If the sensor values exceed the threshold values, the micro-controller switches of the supply to the motor and protects it from further damage. The CPU fan will be switched on automatically if the temperature rises above 34⁰C.

**Communication:** Reports the voltage status and operational data to IOT platform, enabling real-time monitoring through ThingSpeak web application,the temperature and voltage values recorded for every time interval. In this way can monitor the values remotely anywhere with the help of Internet.

**Optimization:** This system improves battery performance and efficiency. The battery can maintain at suitable conditions in such a way that it performs for longer period of time.

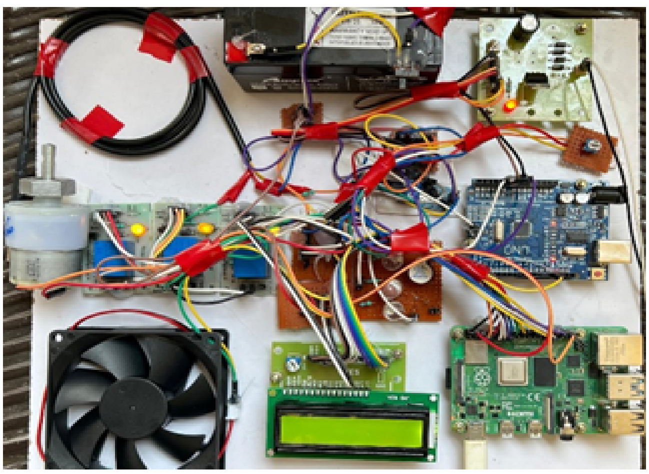

**Figure.10** Reak Time Kit operation

The results displays every movement of the system regarding the voltage and temperature. The LCD screen displays the real-time data including the current values of voltage and temperature. The recorded data gets updated in the display for every cycle. The buzzer indicates the anomalous situations like over-heating or fluctuations in the voltage.

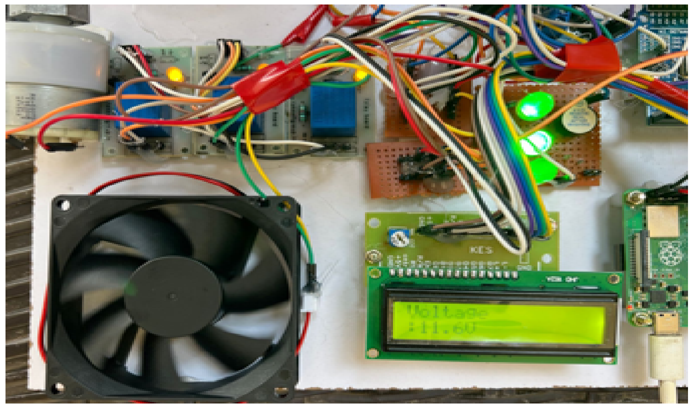

**Figure. 11** Real Time Voltage Display

In the IDLE shell of the Raspberry Pi, the output can be seen for every cycle such that the real-time values can be seen through the terminal running the program. The terminal displays the condition of fan whether it is ON position or not and motor whether it is are in running position or not. For High Temperature the fan will be on automatically as the micro-controller sends the signal to the fan through relay.

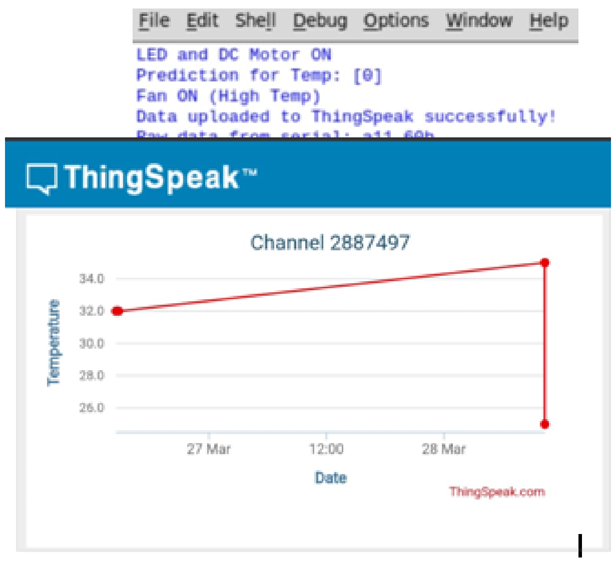


**Figure. 12** Output in Raspberry Pi IDLE

## Remotely Monitored Results

These results from Raspberry Pi gets uploaded to the ThingSpeak platform as the Pi is connected to the internet. The temperature and voltage values can be seen remotely in the ThingSpeak web application with the help of Internet. The ThingSpeak platform provides the results in the form of graphs taking the values from

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the Raspberry Pi and displays the voltage and temperature readings.

The following figure shows the real time voltage display taking the values from the micro-controller and display them based on time interval. The X-axis takes the voltage and Y-axis takes the date and time. By clicking on the cursor point we will get the voltage value at that particular time.

The following figure shows the real time voltage display taking the values from the micro-controller and display them based on time interval. The X-axis takes the temperature readings and Y-axis takes the date and time. By clicking on the cursor point we will get the temperature value at that particular time.

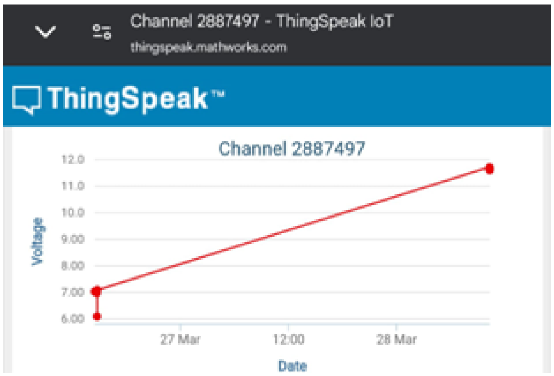


**Figure. 13** Thing Speak Temperature Display

## 4. Conclusion

The "IoT-Based Electrical Vehicle Battery Management System with Charge Monitoring and Fire Protection" represents a significant step forward in the realm of electric vehicle technology. By combining effective monitoring of battery performance with proactive safety measures, this system is poised to enhance the operational efficiency of electric vehicles while mitigating risks associated with battery malfunctions. The integration of IoT technology facilitates real-time data access, enabling both users and manufacturers to make informed decisions regarding battery health and maintenance. As electric vehicles continue to gain popularity, systems like this will play a pivotal role in ensuring their safe and efficient operation.

The future scope of electric vehicle (EV) Battery Management Systems (BMS) includes advancements in battery chemistries, integration with smart grids and vehicle-to-grid (V2G) technologies, AI/ML integration for predictive maintenance, and enhanced cybersecurity measures.

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