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IoT Based Electric Vehicle Battery Management System by Using Charge Monitor And Fire Protection

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Abstract: This paper presents the development of an IoT-based Electric Vehicle Battery Management System with charge monitoring and fire protection. The main aim of this system is to improve the safety, performance, and life of the battery used in electric vehicles. In this system, important battery parameters such as voltage, current, and temperature are continuously monitored using sensors. The collected data is processed using a microcontroller and displayed on an LCD for local monitoring. At the same time, the data is sent to an IoT platform, which allows users to monitor the battery status remotely in real time. The system also includes safety features. If any abnormal condition such as high temperature, over-current, or low-voltage is detected, the system automatically takes protective actions. These actions include turning OFF the motor, stopping charging, activating a cooling fan, and giving alerts through LED indicators and a buzzer. This helps in preventing battery damage and reduces the risk of fire hazards. Overall, this paper provides a simple, low-cost, and effective solution for battery monitoring and protection in electric vehicles. It improves battery reliability, ensures safe operation, and supports efficient energy management.

Keywords: Electric Vehicles (EV'S), Internet of things (IOT), Thingspeak cloud, Real-time monitoring, wifi module.

I. INTRODUCTION

Nowadays, electric vehicles are becoming more popular because they are better for the environment and reduce pollution. Unlike petrol and diesel vehicles, electric vehicles use batteries to run. So, the battery is the most important part of an electric vehicle. The performance of the battery depends on different factors like voltage, current, and temperature. If these values go beyond safe limits, it can damage the battery and may even cause dangerous problems like overheating or fire. Because of this, it is very important to monitor and control the battery properly[1]

To solve this problem, a Battery Management System (BMS) is used. The BMS continuously checks the condition of the battery and keeps it working safely. It also helps to improve the life and efficiency of the battery. In this project, we are using IoT (Internet of Things) technology along with the battery system. IoT helps to monitor the battery data in real time and allows users to check the battery status from anywhere. The system also includes safety features like charge monitoring and fire protection.[2]

So it will help to make the battery system safer, more reliable, and more efficient for electric vehicles.

A. General Background

Electric vehicles (EVs) are becoming increasingly popular across the world due to the growing demand for clean and sustainable transportation. Conventional vehicles that use fossil fuels produce harmful emissions that contribute to environmental pollution and climate change. To overcome these problems, electric vehicles are being widely adopted because they use electrical energy stored in batteries instead of gasoline or diesel. This helps in reducing carbon emissions and improving energy efficiency.The battery is one of the most important components of an electric vehicle because it stores and supplies electrical energy to the motor. Most modern electric vehicles use lithium-ion batteries due to their high energy density, longer life cycle, and better performance. However, these batteries are sensitive to operating conditions such as voltage, current, and temperature. Improper charging, overheating, or excessive current can damage the battery and may even lead to dangerous situations such as battery failure or fire accidents.

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To ensure the safe and efficient operation of batteries, a Battery Management System (BMS) is used. A BMS continuously monitors important battery parameters such as voltage, current, temperature, and state of charge. It helps in controlling the charging and discharging process and protects the battery from conditions like overcharging, deep discharging, and overheating. By doing so, the BMS improves battery life, performance, and safety.With the advancement of modern technologies, the Internet of Things (IoT) has become an effective tool for monitoring and controlling systems remotely. IoT allows devices to communicate with each other through the internet and enables real-time data monitoring from anywhere. By integrating IoT technology with battery management systems, it is possible to monitor battery parameters in real time using cloud platforms or mobile applications.In addition to monitoring, safety is another important concern in electric vehicle batteries. Overheating or internal faults may lead to fire hazards. Therefore, implementing a fire protection mechanism is essential to detect abnormal temperature conditions and prevent accidents. Fire protection systems can provide early warnings and automatically activate safety measures to protect the battery and the vehicle.The proposed IoT Based Electric Vehicle Battery Management System with Charge Monitoring and Fire Protection aims to improve battery safety, efficiency, and reliability. The system continuously monitors battery parameters using sensors and sends the data to an IoT platform for real-time monitoring. If abnormal conditions are detected, the system generates alerts and activates protection mechanisms to prevent battery damage and ensure safe operation.

B. Problem Statement

The problem addressed by the IOT-based battery monitoring system is the need for efficient management, safety and performance optimization by battery packs in various applications, including renewable energy storage and electric vehicles. Current challenges include the lack of real-time monitoring capabilities for critical parameters such as voltage ,current and temperature as well as the absence of proactive measures to prevent damage from overloads or extreme conditions. This project aims to provide a comprehensive solution by integrating advanced sensors, microcontrollers and cloud connectivity to enable remote monitoring, proactive safety measures and operational efficiency for battery systems.

C. Project Justification

The project IoT-Based Electric Vehicle Battery Management System (BMS) is justified due to the rapid growth of electric vehicles and the need for efficient battery monitoring and protection. Batteries are the most important and expensive component in an electric vehicle, and improper management can lead to reduced battery life, overheating, or safety issues. By implementing an IoT-based monitoring system, important battery parameters such as voltage, current, and temperature can be continuously observed in real time. This helps in maintaining the battery within safe operating limits and ensures reliable performance of the electric vehicle.

In addition, integrating IoT technology allows the battery data to be transmitted to cloud platforms for remote monitoring and analysis. This enables users or engineers to access battery information from anywhere and take preventive actions if any abnormal condition occurs. The system improves battery efficiency, increases safety, and supports predictive maintenance. Therefore, this project provides a cost-effective and smart solution for improving battery performance and reliability in modern electric vehicles.

D. Objectives of the project

The main objectives of this project are:

- To design an IoT based Battery Management System for electric vehicles.
- To monitor battery voltage, current, and temperature.
- To implement real-time charge monitoring using IoT.
- To provide fire protection during abnormal conditions.

E. Scope of the project

The scope of the IoT-Based Electric Vehicle Battery Management System with Charge Monitor and Fire Protection is to design and develop a system that can monitor the important parameters of an electric vehicle battery in real time. The system measures battery voltage, current, and temperature using sensors and sends the data to a microcontroller. This information is then displayed locally and also transmitted to an IoT platform for remote monitoring. The charge monitoring feature helps users know the battery status and prevents problems such as overcharging and deep discharge, which can reduce battery life.

Another important scope of this project is to improve battery safety by integrating a fire protection mechanism. If the battery temperature rises beyond a safe limit, the system can detect the abnormal condition and trigger a protective action such as activating an alarm, sending an alert through the IoT platform, or controlling a protection circuit. This project can be applied to electric vehicles, battery-powered systems, and energy storage applications to improve battery performance, safety, and reliability.

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F. Methodology

The project is implemented in the following stages:

- Sensor Stage – Voltage, current, and temperature sensors measure battery parameters.
- Control Stage – A microcontroller processes sensor data.
- IoT Stage – Data is transmitted to a cloud platform for monitoring.

Protection Stage – Fire protection and alert systems activate during abnormal conditions.

II. LITERATURE REVIEW

Gregory L. Plett[1] provided one of the most important contributions to Battery Management Systems (BMS). His work explains that a BMS must continuously monitor key parameters such as voltage, current, temperature, and State of Charge (SOC). These parameters are essential to ensure battery safety, long life, and efficient performance. He also introduced advanced estimation algorithms like Kalman filtering, which help in accurately predicting battery conditions even when direct measurement is difficult. His research forms the theoretical base for designing modern and reliable BMS systems. Hu et al**.** [2] focused on modelling lithium-ion batteries using equivalent circuit models. These models represent the battery using electrical components like resistors and capacitors. Their study explains how battery voltage and current change when different loads are applied. This helps engineers understand battery behavior under real working conditions. Their work is useful for improving battery prediction accuracy, which is important for applications like electric vehicles and energy storage systems.

Al-Fuqaha et al.[3] presented a detailed survey on Internet of Things (IoT) architecture. They explained that IoT systems are divided into different layers such as sensing layer, network layer, and application layer. Sensors collect data, communication protocols transfer the data, and cloud platforms process and display it. Their research highlights how IoT enables real-time monitoring, data storage, and remote access. This is very useful in battery monitoring systems where continuous tracking is required.

Kumar and Pattnaik[4] developed a practical IoT-based battery monitoring system. Their system collects battery parameters like voltage and current using sensors and sends the data to a cloud platform. Users can view this data in real time through a web interface or mobile device. This system improves convenience and helps in early detection of battery issues. Their work shows how IoT can be applied effectively in real-world battery management.

Feng et al.[5] studied the thermal behavior of lithium-ion batteries, especially the condition called thermal runaway. Thermal runaway happens when the battery temperature increases uncontrollably, leading to fire or explosion. Their research identified overheating as a major cause of this problem. They emphasized the importance of temperature monitoring and early warning systems. This study is very important for improving battery safety in electric vehicles and other applications.

Ravi and Mahalakshmi [6] designed an embedded battery protection system using a microcontroller. Their system continuously checks battery conditions and disconnects the battery automatically when a fault is detected, such as overvoltage, overcurrent, or overheating. They used relays and control logic to ensure quick response. This improves the safety and reliability of the battery system by preventing damage and accidents.

ThingSpeak [7] is a cloud-based IoT platform used for collecting, storing, and analyzing data from sensors. It allows users to visualize data in the form of graphs and charts in real time. It also supports data analysis using MATLAB tools. Overall, these studies show that combining Battery Management Systems with IoT technology improves monitoring, safety, and performance. Accurate parameter estimation, real-time data tracking, and early fault detection are the key factors for developing an efficient and safe battery system.

III. BLOCK DIAGRAM

A. Components used and its functionality:

NodeMCU (ESP8266): The NodeMCU acts as the main controller of the system. It collects data from all sensors such as voltage, current, and temperature sensors and processes this information. The NodeMCU also compares the measured values with predefined safety limits. If any abnormal condition occurs, it activates safety actions like turning OFF the motor, stopping charging, and turning ON the cooling fan. It also sends the battery data to the IoT cloud for remote monitoring.

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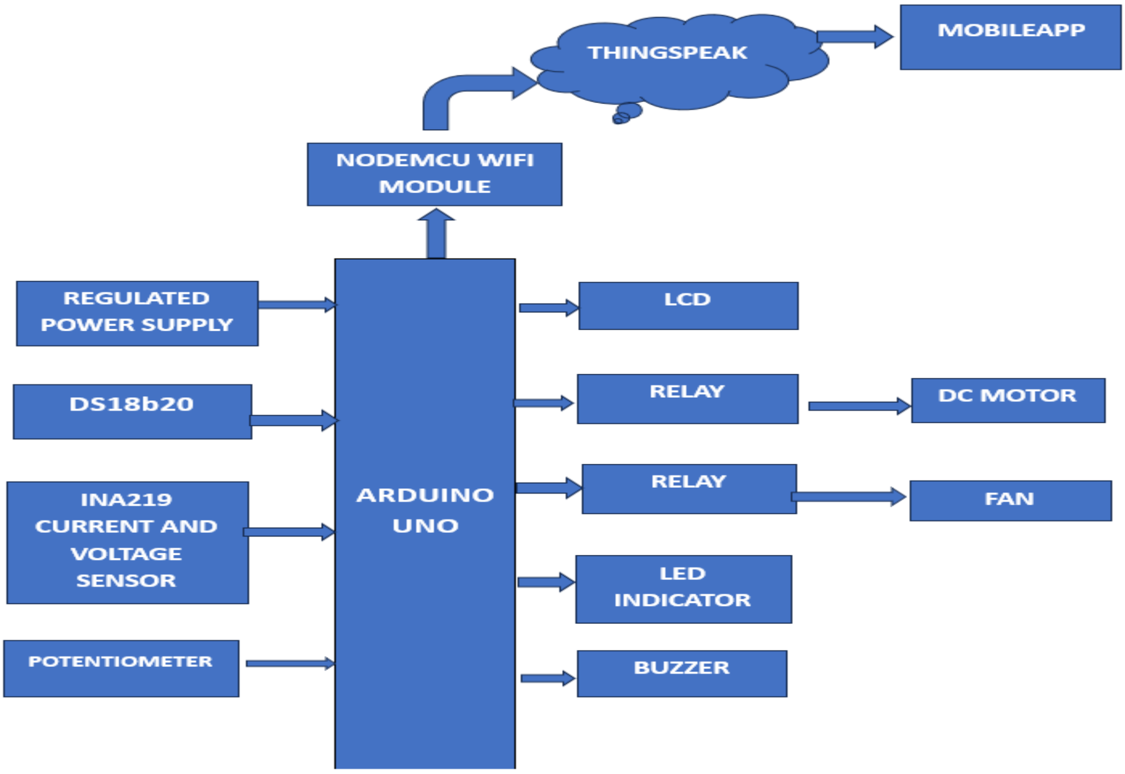

Fig 1: Block diagram

INA219 Current and Voltage Sensor: The INA219 sensor is used to measure the battery voltage and current consumption in real time. It continuously monitors how much current is flowing through the battery and the voltage level of the battery pack. This information helps in identifying abnormal conditions such as over-current or over-voltage, which can damage the battery or cause overheating.

DS18B20 Temperature Sensor: The DS18B20 temperature sensor is used to monitor the battery temperature continuously. If the temperature increases beyond the safe limit, it indicates a risk of overheating or fire hazard. The sensor sends this temperature data to the NodeMCU so that the system can activate protection mechanisms like turning ON the cooling fan.

LCD Display (16×2): The 16×2 LCD display is used to show the real-time battery parameters such as voltage, current, and temperature. This allows the user to locally monitor the battery status without needing to check the IoT platform.

Relay Module: The relay module works as an automatic switch to control high-power devices. It is used to disconnect the motor or charging supply when unsafe conditions such as over-current or over-voltage occur. This helps in protecting the battery and preventing system damage.

Cooling Fan / DC Motor: The cooling fan is used to reduce the battery temperature when overheating occurs. When the temperature exceeds the safe limit, the NodeMCU activates the fan to cool down the battery and prevent fire hazards.

LED Indicators: The LED indicators provide visual alerts when the system detects abnormal conditions. For example, when over-temperature or over-current occurs, the LEDs turn ON to warn the user about the fault in the system.

Potentiometer: The potentiometer is used during testing to simulate changes in battery voltage. By adjusting the potentiometer, different voltage levels can be created to check how the system reacts to abnormal conditions.

Power Supply Unit: The power supply unit provides the required electrical power to operate the NodeMCU, sensors, LCD display, and other components in the system.

Connecting Wires: The connecting wires are used to physically connect all the electronic components together and complete the circuit of the system.

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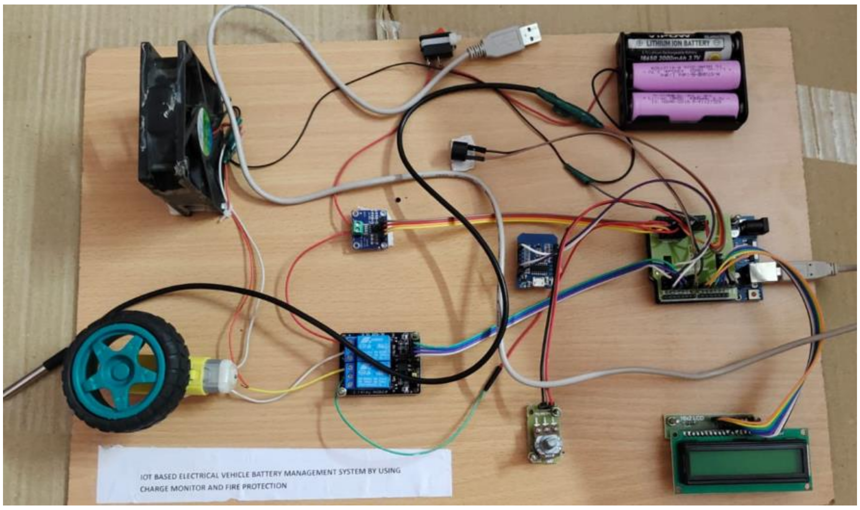

Fig 2 connection kit

B. Working:

Input Sensing Section: This section continuously measures important battery parameters:

- ➢ **Voltage Sensor:**
- Measures the battery voltage level to detect over-voltage or under-voltage conditions.
- ➢ **Current Sensor (INA219):**
- Measures the battery charging/discharging current to identify over-current situations.
- ➢ **DS18B20 Temperature Sensor:**
- Monitors battery temperature in real time to prevent overheating and thermal runaway.
- ➢ **Potentiometer:**
- Used for testing and simulating voltage variations during demonstration.
- All these sensors send real-time data to the controller.

Processing & Control Unit:

- ➢ **NodeMCU (ESP8266):**

The NodeMCU acts as the central controller of the system

Its functions include:

- Collecting data from all sensors
- Comparing measured values with predefined safety limits
- Making decisions based on abnormal conditions
- Sending data to the IoT cloud platform

It performs both control operations and wireless communication

Output / Protection Section: Based on the controller's decision:

- ➢ **Relay Module:**
- Cuts off motor supply during over-current condition
- Disconnects charging during over-voltage condition
- ➢ **Cooling Fan:**
- Automatically turns ON during over-temperature condition
- ➢ **LED Indicators:**
- Provide visual alert during fault conditions
- ➢ **LCD Display (16×2):**
- Displays real-time voltage, current, and temperature locally

This section ensures automatic safety protection of the EV battery.

IoT Communication Section:

- The NodeMCU uploads live battery data to ThingSpeak IoT Cloud.
- Data can be monitored remotely using:
  - Web dashboard
  - Mobile application (MIT App Inventor)

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C . Advantages:

- **Improved Battery Safety :** Fire protection systems detect overheating, short circuits, or thermal runaway and prevent battery fires.
- **Real-Time Charge Monitoring :** Continuously monitors battery voltage, current, and temperature to ensure safe charging and discharging.
- **Extended Battery Life :** Prevents overcharging and deep discharging, which increases the lifespan of the EV battery.
- **Efficient Energy Management :** Optimizes power usage and improves overall vehicle efficiency.
- **Early Fault Detection :** Identifies abnormal conditions such as overcurrent, overheating, or cell imbalance before serious damage occurs.
- **Remote Monitoring with IoT :** Allows users or operators to monitor battery status remotely through mobile apps or cloud systems.
- **Thermal Management :** Maintains battery temperature within a safe range to avoid overheating.

D . Applications:

- EV Battery Charging Stations
- Smart battery management systems
- Industrial electric vehicles
- Electric cars,bikes and scooters
- Smart transportation and e-mobility solutions
- Research and educational EV platforms

IV. RESULT

Voltage (VOL) vs Date : The voltage graph shows how the battery voltage changes over time. At first, the voltage is around 10V, then it drops to about 7V, indicating battery discharge. After that, the voltage remains nearly stable with a slight increase. Toward the end, there are sudden fluctuations, where the voltage rises close to 12V and drops sharply again. These variations may occur due to charging cycles, load changes, or switching conditions in the Battery Management System (BMS).

Current (CURR) vs Date: The current graph represents the flow of current in the system. Initially, a small current is observed, which gradually decreases to nearly 0A, indicating no load or idle condition. Later, sudden spikes in current (up to around 230A) are seen, followed by quick drops. These spikes indicate high power demand or sudden load application. The irregular pattern suggests dynamic operating conditions of the battery system.

Temperature (TEMP) vs Date: The temperature graph shows the variation of battery temperature over time. At first, the temperature is around 34°C, then it gradually decreases to about 30°C. Later, multiple fluctuations occur between 30°C and 35°C. These changes indicate heating and cooling cycles of the battery, which may be caused by charging/discharging processes or environmental conditions. Monitoring temperature is important to ensure battery safety and avoid overheating.

Fig 1 Voltage vs date graph

Fig 2 Current vs date graph

Fig 3 temperature vs date graph

The temperature shows over temperature whenever the value exceeds the predetermined value.

Fig 4 over temperature

The voltage shows low voltage whenever the voltage decreases than the predetermined value.

Fig 5 Low voltage

The current shows high current whenever the value exceeds the predetermined value.

Fig 6 High current

V. CONCLUSION

The IoT-based Electric Vehicle Battery Management System developed in this project successfully monitors important battery parameters such as voltage, current, and temperature in real time.By integrating sensors with the Arduino UNO and NodeMCU modules, the system provides both local monitoring through the LCD display and remote monitoring using the ThingSpeak cloud platform. The implemented protection mechanisms automatically respond to abnormal conditions like over-temperature, over-current, and low voltage by activating safety actions such as buzzer alerts, motor shutdown, relay cutoff, and cooling fan operation.This helps in preventing battery damage, reducing fire risk, and improving overall battery safety and reliability. Therefore, the proposed system demonstrates an effective and low-cost solution foenhancing the performance, safety, and lifespan of electric vehicle batteries using IoT-based smart monitoring.

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