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# IoT-Based Battery Management Systems and Monitoring for Electric Vehicles

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***KEYWORDS***

*Internet of Things (IoT), Battery Management System, Battery, user interface, Arduino, Electric Vehicles.*

**ABSTRACT**

*Since EV batteries are the main energy source for these vehicles, the Internet of Things (IoT) is essential to their management and monitoring. Vehicle efficiency is decreased as a result of the battery's performance gradually declining as it discharges over time. This decline in battery health is a significant worry for both manufacturers and users. To solve this issue, this study presents an IoT-based battery monitoring system designed to continuously track the performance of the battery and deliver real-time information. An interface and a monitor are the two primary parts of the system. Important variables including voltage, temperature, and charge/discharge cycles are continuously monitored by the monitor. It detects any decline in performance and guarantees that the battery runs in ideal circumstances.*

## 1. INTRODUCTION

Battery Management System for Electric Vehicles (EVs) Based on the Internet of Things The automotive industry's quick adoption of electric vehicles (EVs) has brought attention to how important battery performance is in determining the overall dependability and efficiency of EVs. Since the battery is an EV's main energy source, it has a direct effect on the vehicle's longevity, charging time, and driving range. Since rechargeable lithium-ion or comparable batteries power these cars, maintaining the battery's condition and performance is crucial to guaranteeing optimum vehicle performance. This is where the idea of a Battery Management System (BMS) based on the Internet of Things (IoT) enters the picture The health, performance, and safety of EV batteries are tracked and managed in real time by an Internet of Things (IoT)-based Battery Management System (BMS), which combines cutting-edge sensors, communication modules, and cloud computing technologies. It ensures that the battery runs within safe and effective bounds by continuously monitoring vital factors like temperature, voltage, current, and battery charge. The system's usage of IoT technology allows users, manufacturers, and service providers to track battery performance remotely in addition to providing real-time monitoring. By identifying anomalies like overcharging, overheating, or voltage imbalances, this intelligent monitoring system can provide early warnings to stop battery failure or degeneration. Additionally, by optimising charging cycles, providing predictive maintenance alerts, and sending information about the battery's condition, including state of charge (SOC) and state of health (SOH), IoT-based BMS All things considered, the Internet of Things-based Battery Management System is a crucial advancement in guaranteeing the long-term The main aim of this design is to formulate the BMS for EVs with the primary goal of enhancing the overall health of the battery.The monitoring system will regularly track various health parameters such as voltage, current and temperature, the entire system uses a arduino module to transmit the data to the cloud. The device has an inbuilt LCD display to show the status of the sensors visually.

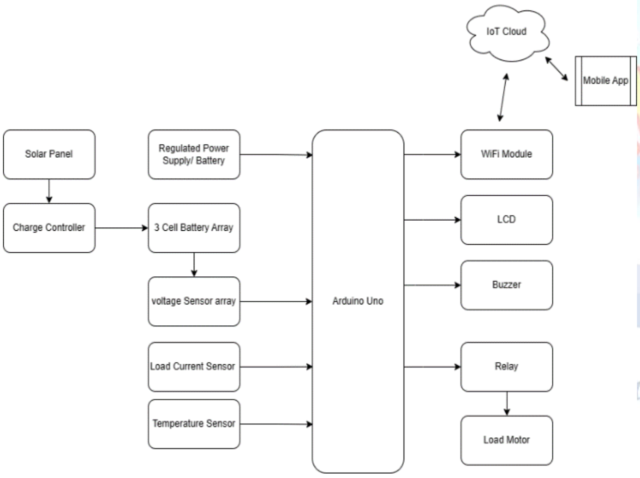


Fig. Block Diagram

An intelligent, Internet of Things-enabled solar powered system with automated control, remote monitoring, and effective energy management is depicted in the block diagram. In order to ensure safe and efficient charging of a 3-cell battery array, the system begins with a solar panel that collects solar energy and sends it to a charge controller that controls the power flow. The voltage is further stabilised by a controlled power source, which gives the system dependable energy. To guarantee safe operation, a number of sensors—including a voltage sensor array, load current sensor, and temperature sensor—continually track important variables like battery voltage, current usage, and temperature fluctuations. The Arduino Uno is the central component of the system, processing data from these sensors and managing different output components. The WiFi module connects to the Internet of Things cloud, allowing users to monitor and control the system remotely through a mobile app and transmit data in real time. While the buzzer warns users of serious problems including overheating, low battery, or system malfunctions, the LCD display gives instant feedback on system data. Furthermore, a relay is included in to regulate a load motor, which can be turned on or off in response to remote commands or preset conditions.

This system provides an intelligent, automated, and energy-efficient way to manage loads, optimise power consumption, and guarantee smooth remote operation by utilising renewable energy and Internet of Things technologies. Because of this, it is ideal for use in smart grids, home automation, industrial energy management, and other fields that call for integrated and sustainable solutions.

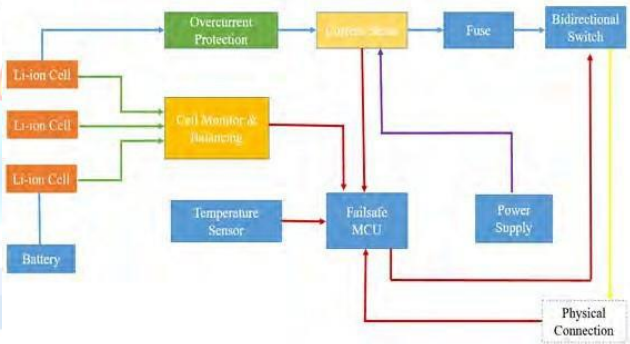


Fig.2. Flowchart of BMS in EV

A complete Battery Management System (BMS) for lithium-ion (Li-ion) cells that guarantees longevity, safety, and efficiency is depicted in the flowchart. The "Cell Monitor & Balancing" equipment monitors and balances a battery pack that is initially connected to several Li-ion cells. By distributing charges evenly among cells, this unit guards against overcharging or undercharging. An "Overcurrent Protection" device is incorporated to improve safety. It reduces the chance of damage or overheating by detecting and mitigating excessive current flow. The central controller is a "Failsafe MCU" (Microcontroller Unit), which gets vital inputs from a "Temperature Sensor" and a "Cell Monitor & Balancing" system. The MCU can take the appropriate actions to stop thermal runaway since the temperature sensor continuously monitors heat levels. Additionally, the MCU controls power flow using a "Fuse" and a

"Bidirectional Switch," ensuring safe and effective energy distribution. A "Power Supply" module is also included in the system to ensure that all of its parts operate steadily. A smooth and dependable power management method is ensured by the physical connections that link the complete framework.

This BMS improves battery performance, prolongs lifespan, and guarantees safe operation in a variety of applications, including electric vehicles, renewable energy storage, and portable devices, by combining cutting-edge monitoring, protection, and control techniques.


Fig.3.Arduino uno

A popular and adaptable microcontroller board, the Arduino Uno is made for both novice and expert creators. The ATmega328P microcontroller, which powers it, operates at 16 MHz, enabling dependable and quick operation. The Uno has six analogue inputs for connecting to sensors and other devices, as well as fourteen digital I/O pins, six of which are capable of generating Pulse Width Modulation (PWM) signals. The board is adaptable and compatible with a range of power sources thanks to its 5V operational voltage and 7–12V input voltage range. Because of the Arduino IDE, programming the Arduino Uno is simple. Even people with little to no programming knowledge can use this software to write code in a simplified version of C/C++. The USB connector, which also supplies power to the board, can be used to upload the code once it has been written. The Uno may be used for both small and large projects because it can be powered by a VIN pin or its barrel jack. Prototyping, do-it-yourself projects, and educational settings are common uses for the Arduino Uno. It performs exceptionally well in activities like task automation, robot construction, interactive art, motor control, and sensor data reading.


Fig.4.Voltage sensor

One essential part for measuring the voltage, or potential difference, in an electrical circuit is a voltage sensor. Its purpose is to give a reading of the voltage between two places, which provides important information about how well an electronic system is working. Applications for voltage sensors are numerous and include solar power monitoring, power supplies, battery management systems, and energy-saving initiatives. For systems that need precise voltage readings, analogue voltage sensors are perfect since they continuously produce a voltage signal proportionate to the measured voltage. Normally, a voltage divider circuit is used in an Arduino-based setup to reduce the input voltage to a level that the Arduino's analog-to-digital converter (ADC) can safely read, which is normally between 0V and 5V. For instance, two resistors can be used to lower a high voltage, resulting in a safe, proportionate voltage that the Arduino can understand. After processing the sensor's output with the analog read function, a determined voltage can be shown or utilised for other purposes, including initiating actions based on the voltage threshold. By supplying precise and up-to-date voltage data, these sensors play a crucial role in managing and protecting electrical devices in applications such as solar energy systems, over-voltage protection, and battery level monitoring.

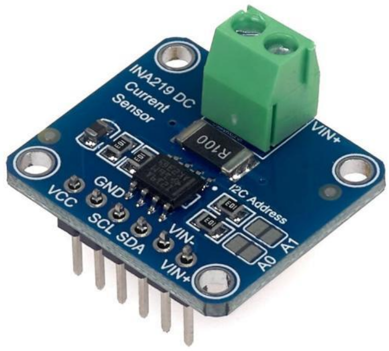


Fig.5.Current sensor

A device that detects and measures the electric current flowing through a wire or circuit is called a current sensor. From electrical system monitoring to overload protection for circuits, these sensors are essential in many applications. These are a few typical kinds of current sensors. Knowing Current Sensors: In electrical systems that detect the flow of electric current through a conductor, current sensors are essential parts. Energy monitoring, circuit protection, and making sure electrical systems are operating correctly are just a few of the many uses for these sensors. They function by either measuring the voltage drop across a resistor connected in series with the current flow or by detecting the magnetic field produced by current-carrying wires.

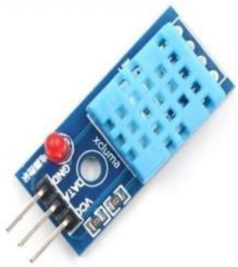

Fig.6.Temperature sensor

One tool for measuring temperature is a temperature sensor. From common consumer electronics to industrial automation, these sensors are essential to many different sectors and applications. Temperature sensors pick up temperature variations and translate them into an electrical signal that a system or gadget can read. They operate according to diverse principles and take many different forms. Some of the most popular kinds of temperature sensors and their uses are listed below.

In many different industries, temperature sensors are essential to preserving system performance, safety, and efficiency. They are made to deliver precise, dependable data in real time, facilitating automation and crucial decision-making. They make it possible to continuously monitor high-temperature processes in industrial systems, avoiding dangerous circumstances or equipment damage. They prolong the life of consumer electronics by controlling heat dissipation to safeguard sensitive parts. Furthermore, by tracking body temperature, temperature sensors in medical applications guarantee the best possible treatment for patients, and in the automotive sector, they enhance engine efficiency and performance. These sensors continue to develop as technology progresses, providing increased accuracy and adaptability.

Fig.7.Relay module

Relay modules are electronic devices that function as switches, enabling low-voltage signals to be used to operate high-voltage electrical circuits. Motors, lights, fans, and other appliances that need more power than the microcontroller can supply directly are frequently controlled using it in microcontroller-based projects (such as those involving Arduino, Raspberry Pi, or other microcontrollers). Because they can connect low-voltage control circuits to high-voltage power circuits, relay modules are a crucial part of many different types of electronics and automation systems. Using microcontrollers like Arduino or Raspberry Pi, they offer a simple method of automating and controlling electrical items like lights, fans, motors, and more. Relay modules ensure system and operator safety and longevity by providing electrical isolation, which shields delicate control electronics from high-voltage spikes. Because of their adaptability, they may be used in robotics, home automation, industrial automation, and even automotive systems, offering dependable control and switching.

Fig.8. LCD Display

The flat-panel display technology known as an LCD (Liquid Crystal Display) is frequently seen in a wide range of gadgets, including digital clocks, calculators, cellphones, televisions, computer displays, and even embedded systems like microcontroller projects. Because of their low profile, high-quality text and image display, and energy efficiency, LCDs are frequently used.

Because of their high-quality output, low power consumption, and mobility, LCD displays have become essential to modern technology. Because of their capacity to deliver understandable, clear information in a variety of settings, they are extensively utilised in consumer electronics as well as industrial applications, medical devices, and automobile displays. Furthermore, LCDs are now even more dependable in high-performance applications with to advancements like IPS (In-Plane Switching) technology, which has increased viewing angles and colour consistency. Future advancements in display technology have been made possible by the creation of flexible LCD panels, which have further increased their application in wearables, folding gadgets, and other cutting-edge technologies.

## II. WORKING

In electric vehicles (EVs), an Internet of Things (IoT)-based Battery Management System (BMS) is essential since it makes sure the battery runs effectively, safely, and for as long as feasible. To efficiently and intelligently maintain the battery pack, it integrates wireless connection, data processing, real-time monitoring, and cloud-based analytics. An IoT-based BMS starts operating as soon as the car is turned on. All of the embedded sensors now begin to operate when the BMS initialises its microprocessor. Essential battery properties including voltage, current, temperature, and more are measured by these sensors, which are positioned across individual battery cells. Analog-to-digital converters (ADCs) digitise these values before sending them to the primary controller for processing. Every battery cell provides real-time data to the BMS continually. Each cell's voltage level, the total current entering and leaving the battery pack, the temperature of the cells, and other crucial indicators such as the State of Charge (SoC) and State of Health (SoH) are all included in this. The system may use this information to assess each cell's health, the amount of energy remaining in the battery, and the presence of any safety hazards like overcharging or overheating. The communication capabilities of the IoT-based BMS is one of its primary features. Data processing modules such as Wi-Fi, 4G, or NB-IoT are used to send the processed data to the cloud. This data is transmitted to a cloud server via secure protocols like MQTT or HTTP, where it is stored, displayed, and subjected to additional analysis. Artificial intelligence and machine learning can be used by cloud-based applications to identify battery usage trends, anticipate possible malfunctions, and enhance performance. Using web dashboards or mobile apps, users including fleet managers, eye on the battery's condition in real time. If an anomalous condition is found, like a quick loss in charge or a rise in temperature, they are notified. This enables them to prevent malfunctions or safety risks and act promptly. In more sophisticated systems, cloud servers can also communicate with the BMS to carry out remote tasks like modifying charging rates, unplugging malfunctioning modules, or planning charging for off-peak times.

To sum up, an Internet of Things (IoT)-based battery management system in electric cars guarantees ongoing observation, boosts battery efficiency, increases safety, and permits smart decision-making via cloud analytics and remote access. This technology is essential to the development of intelligent and effective electric mobility.

## II. HARDWARE OUTPUT

The necessity of effective and secure battery management systems (BMS) has been brought to light by the rising demand for electric cars (EVs). A BMS extends the battery pack's lifespan and performance while guaranteeing that the battery cells operate within safe bounds. This project shows a working prototype of an Internet of Things (IoT) based battery management system that uses an Arduino and an ESP8266 to monitor, safeguard, and operate an EV battery arrangement in real time. For demonstration, the hardware is constructed on a wooden board and comprises of multiple integrated components. An Arduino Uno sits in the middle, serving as the primary controller and connecting to all of the sensors and modules. Additionally embedded is a NodeMCU (ESP8266), which offers Wi-Fi capability for sending battery data to a mobile application or the cloud. Real-time data, including temperature, humidity, and battery voltage, are displayed on a 16x2 LCD screen. Two 18650 lithium-ion batteries, which stand in for the EV's battery cells, are used to replicate the power source. These mimic solar charging by being attached to miniature solar panels. As a sustainable energy source, the solar panel powers the batteries and exemplifies how green energy may be integrated into EV systems. The Arduino receives real-time data from a voltage sensor that keeps an eye on the battery levels. The DHT11 temperature and humidity sensor is used to replicate thermal and environmental conditions. Because overheating might result in thermal runaway or cell damage, it is imperative to keep an eye on the battery's temperature for safety. The system has the ability to initiate a safety response in the event that abnormal temperature levels are detected. To regulate the power flow, the project incorporates a relay module that functions as a switch. To avoid damage, the relay cuts the battery off from the load or charging source in critical circumstances like overcharging, overdischarging, or overheating. The setup's gear motor helps visualise power delivery under various circumstances by simulating an EV's load or driving mechanism. The system's IoT capabilities is one of its most notable characteristics. Data from the Arduino is gathered by the NodeMCU and wirelessly sent to a web server or cloud platform like Thingspeak or Blynk. This enables customers to remotely check the temperature, charge level, and health of the battery using a PC or smartphone. Design flexibility is demonstrated by the fact that the complete system is powered by a combination of USB and battery input. Users can replicate real-time situations such as system reboot, load disconnect, or manual safety cut-off by using the switches that are available for manual control. To sum up, this prototype successfully illustrates the essential features of an intelligent BMS made for EV applications. It integrates IoT connectivity, safety protection, and real-time data collection into a single, small solution. For a complete commercial BMS, this scalable configuration can be further improved with other features like GPS tracking, cell balancing, current sensing, and smartphone notifications. This idea is a future-ready answer to the problems associated with electric mobility since it integrates renewable energy, has smart protective measures, and uses wireless monitoring.

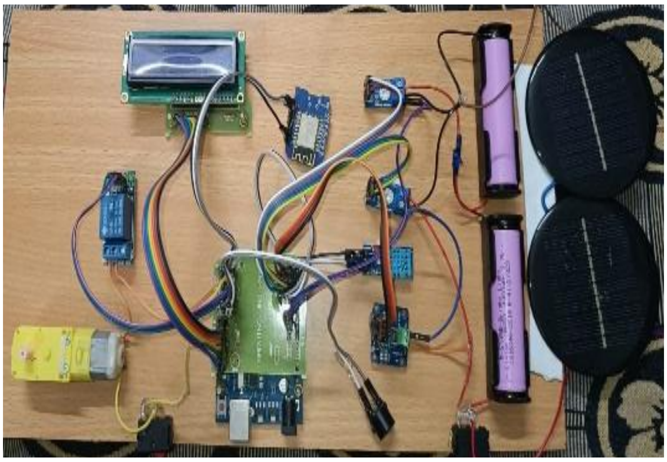

Fig.9. Implementation Of Hard Ware Design



Fig.10 A: Current Fig.10B:Temperature



Fig.10C:Voltage 1 Fig.10D:Voltage 2


Fig.10E:Bus Voltage

## III. CONCLUSION

To sum up, the Internet of Things (IoT)-based Battery Management System (BMS) for Electric Vehicles successfully illustrates an intelligent, real-time EV battery monitoring and control system. This solution guarantees battery safety, efficiency, and a longer lifespan by combining sensors, microcontrollers, relays, and Internet of Things modules. It can immediately disconnect the load in dangerous situations and provide real-time data on vital factors like temperature and voltage. IoT integration makes it possible to monitor remotely using web or mobile applications, which makes it ideal for contemporary EV applications. The groundwork for intelligent, sustainable, and scalable battery management systems in electric vehicles is laid by this project.

### Conflict of interest statement

Authors declare that they do not have any conflict of interest.

## REFERENCES


[1] "Internet of Things (IoT) based Battery Management System" Authors: A. B. Bhat, P. S. Nair Published in: 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT) DOI:10.1109/ICASERT.2019.8934672 Summary: Discusses the integration of IoT with BMS for monitoring parameters like temperature and voltage in real-time.

[2] "IoT-Based Smart Battery Management System" Authors: B. S. Karthik et al. Published in: International Journal of Engineering Research & Technology (IJERT),2020 Link:IJERT-V9IS060436 Summary: Explores real-time battery data transmission using IoT for safe and efficient EV battery operation.

[3] "Design and Implementation of an IoT based Smart Battery Management System" Authors: D. Ghosh, R. Roy Published in: 2021 IEEE 6th International Conference on Computing, Communication andAutomation(ICCCA) DOI:10.1109/ICCCA52192.2021.9666353 Summary: Presents a practical design and testbed for IoT-enabled battery health monitoring and remote alerts.

[4] "Smart Battery Monitoring System using IoT for Electric Vehicles" Authors:T.R.Gopal,R.Vijay Published in: International Research Journal of Engineering and Technology (IRJET), 2022 Link:www.irjet.net Summary: Focuses on using Arduino and NodeMCU for IoT-based smart BMS prototypes.

[5] "IoT Based Battery Management System forElectricVehicle" Authors:P.Kumar,N.Sharma Published in: International Journal of Scientific Research in Engineering and Management(IJSREM),2021 Link:www.ijsrem.com Summary: Describes how real-time battery status is sent to users through IoT, enhancing battery safety and lifespan.