IOT BASED ELECTRIC VEHICLE BATTERY MANAGEMENT SYSTEM WITH CHARGE MONITORING AND FIRE PROTECTION

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I. ABSTRACT

The IoT-Based Electric Vehicle Battery Management System (BMS) with Charge Monitoring and Fire Protection is designed to improve the safety, efficiency, and reliability of electric vehicle operations. This system utilizes an Arduino to monitor key battery parameters such as voltage, current, and temperature, providing real-time feedback through an I2C LCD display. LEDs serve as indicators for battery status and operational conditions. The integration of a NodeMCU module allows continuous data upload to the ThingSpeak IoT platform, enabling remote monitoring, analytics, and proactive maintenance. Safety is enhanced through fire detection and thermal management: if abnormal temperature levels are detected, relays trigger a CPU fan and can isolate the battery to prevent hazards. Adjustable potentiometers and slide switches provide user-defined control over thresholds and manual operation. A DC motor simulates vehicle load, powered by a 12V battery system supported by adapters and power supplies. Supplementary components, including multi-mobile charger cables, female power jacks, and connectors, facilitate flexible integration. The proposed system demonstrates a scalable, energy-efficient, and robust solution for EV battery management, combining IoT monitoring, energy optimization, and fire safety into a single prototype.

KEYWORDS: IOT**,** Battery Management System (BMS), Fire Protection, Charge Monitoring, Electric Vehicle (EV)

II.INTRODUCTION

The rapid growth of electric vehicles has increased the need for efficient and reliable battery management systems to ensure safe and optimized operation. An Electric Vehicle Battery Management System (BMS) plays a vital role in monitoring battery health, performance, and safety parameters. The proposed IoT-Based EV Battery Management System integrates modern sensing and communication technologies to supervise battery voltage, current, and temperature in real time. Using an Arduino controller, the system continuously processes battery data and abnormal operating conditions. Automatic control of cooling mechanisms and battery isolation prevents overheating and potential hazards. User-adjustable controls allow flexible threshold configuration and manual operation when required. Overall, the system presents an intelligent, safe, and scalable solution for next-generation electric vehicle battery management.

Fig.1.Charge Monitoring System

The Battery Management System plays a pivotal role in any electric vehicle which comprise of monitoring, controlling safeguarding the battery pack and thereby certifying the optimal conduction, permanence and safety. The sophisticated functions of BMS varying from real-time monitoring of individual cell parameter to controlling thermal conditions during the charging and discharging cycles in the battery. As electric vehicle technology continues to make headway, the integration of Artificial Intelligence (AI) and Machine Learning (ML) algorithms for estimation analysis, enabling dynamic maintenance and intensifying overall system efficiency.

named as solid-state batteries, lead-acid batteries, ultracapacitors, nickel-metal hydride batteries, lithium-ion batteries. In current scenario, we are utilizing Lithium-ion Batteries as they are much effective and preferred type. Temperature affects these batteries to a greater extent.

Lithium-ion batteries have emerged as the keystone of energy storage in Electric Vehicles (EVs), uprising the automotive industry by providing a high-density and lightweight solution. Lithium-ion battery manages the performance, longevity and safety of electric vehicle effectively. There is a parameter called State of Charge(SoC) which demonstrate the remaining charge of battery in EVs as cars, bicycles, etc, All the electric vehicles if not operated under SoC then they could be dangerous. SoC cannot be considered as constant parameters and should be varied or integrated which achieve the appropriate charger design. During charging and discharging process, parameters as voltage, current, temperature should be monitored to operate the vehicle under SOC. Numerous methods are there for the estimation the SoC of Electrical Vehicles but now-a-days Extended Kalman Filtering method shows the best results till now.[9] Slow (220V-16A) and fast charging (400V-70A) affects the battery parameters as well as network grid.For enhancing the remote monitoring of battery parameters, Internet of Things (IoT) is introduced. The integration of Internet of Things(IoT) technology with Battery Management System represents a radical change real- time monitoring and managing of Electric Vehicles. It enhances the overall efficiency and safety of the system.

Traditional Electric Vehicle Battery Management Systems (BMS) primarily focus on monitoring battery parameters such as voltage, current, and state of charge using basic sensors. Feedback is typically provided via onboard displays or gauges, and manual intervention is often required to manage battery health. Fire protection and thermal management are generally limited or absent, making the system prone to hazards under abnormal conditions. Remote monitoring is rare, and real-time data analytics through IoT platforms are not commonly implemented, reducing the ability to predict and prevent failures effectively.

III. LITERATURE SURVEY

1.Cloud Computing and Remote Monitoring

- Large-Scale Management: Research focuses on managing lithium-ion battery systems over cloud computing, providing an overview of algorithms for health monitoring and fault diagnosis.
- Real-Time Data: Systems have been developed to monitor voltage, current, and temperature in real time via cloud platforms, specifically to prevent battery venting caused by overcharging.
- Condition Estimation: Small-scale cloud simulators have been used to accurately estimate individual cell resistances, capacities, and State of Charge (SoC) through hyperthreading condition monitoring algorithms.

2.Advanced Sensing and IoT Solutions

- Sensor Integration: Some methods suggest using Built-in positive temperature coefficients and NDIR sensors specifically for the detection of CO_2.
- Wireless Connectivity: IoT-based approaches often incorporate Wireless Battery Monitoring Systems (WBMS) using MQTT servers and middle-ware application servers for data transmission.
- Mobile Interaction: Bluetooth-based wireless systems allow for data to be displayed on personal computers or smartphones, showing real-time parameters like temperature and voltage.

3.State of Charge (SoC) Estimation Methods

- Algorithm Performance: While several methods exist, the Extended Kalman Filtering (EKF) method has historically shown strong results for estimating SoC.
- Hybrid Models: Newer adaptive methods combine conventional coulomb counting with EKF correction. This hybrid approach reduces complexity by 70% compared to standard EKF while maintaining an error margin within 2%.

4.Charging Impacts and Infrastructure

- Network Impact: Studies show that fast (400V-70A) and slow (220V-16A) charging have different impacts on the battery and the utility grid, depending on regional factors like peak load during winter.
- User Assistance: IoT integration helps drivers locate nearby charging stations and provides GPS-based location tracking via Google Maps applications.

IV .PROPOSED MODEL

The proposed IoT-Based Electric Vehicle Battery Management System enhances safety, efficiency, and real-time monitoring capabilities. It integrates an Arduino to continuously monitor voltage, current, temperature, and fire conditions, displaying live data on an I2C LCD. LEDs indicate system status, while adjustable potentiometers and slide switches allow customizable thresholds and manual control. A Node MCU module connects the system to the Thing Speak IoT platform, enabling remote monitoring, analytics, and early alerts. Safety is reinforced through relays that control a CPU fan and isolate the battery if overheating or fire is detected. A DC motor simulates vehicle load, while additional components like multi-mobile charger cables and connectors ensure flexible

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integration. This model offers a scalable, energy efficient, and robust solution that combines IoT monitoring, energy management, and fire protection, advancing conventional BMS designs.

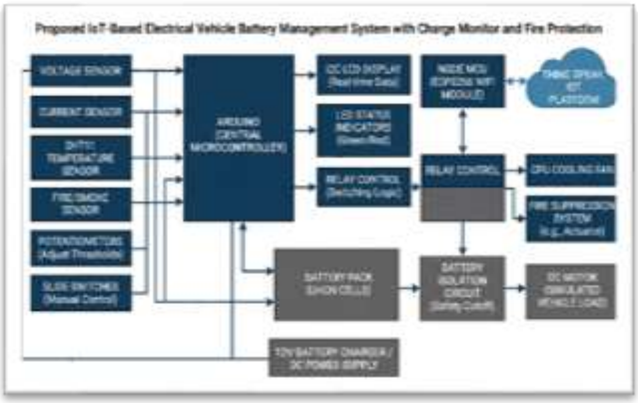


Fig.2.Block Diagram of Proposed Methodology

Table:1:Comparision of BMS and Without BMS in EV

Feature/Parameter	With IoT-Based BMS	Without/Outside BMS Safe Operation Area (SOA)
Safety & Protection	Provides fire protection and automatic power cut-off during abnormal conditions.	High risk of battery venting or explosion due to overcharging or thermal runaway.
Real-Time Monitoring	Continuous tracking of voltage, current, and temperature via LCD and Android/IoT platforms.	No visibility into individual cell parameters, leading to "dangerous" operating states.
Thermal Management	Automatically activates a cooling fan if temperatures exceed 50 degree celcius.	Batteries are highly sensitive to temperature; lack of cooling leads to rapid degradation.
Battery Longevity	Enhances the life cycle and permanence of the battery pack	Permanent damage to cells and significantly reduced life expectancy.

V. BLOCK DIAGRAM:

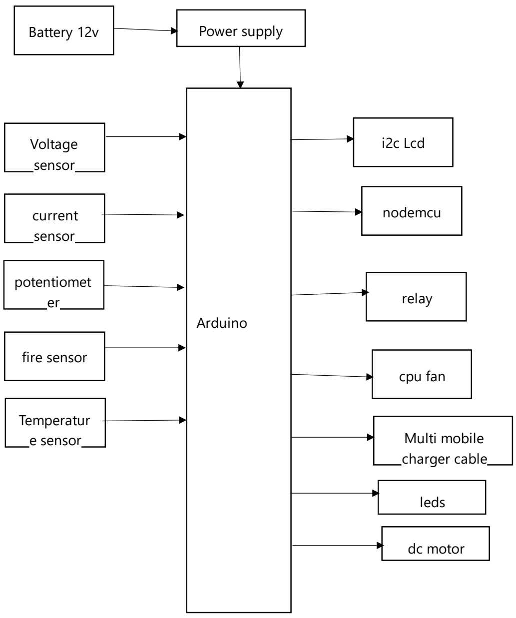


Fig.3.Block Diagram

Table:2:HARDWARE COMPONENTS

S.NO	HARDWARE COMPONENTS
1	Arduino i2c
2	i2c Lcd
3	Voltage and Current Sensors
4	potentiometer
5	Temperature and Fire Sensors
6	Nodemcu
7	relay-4
8	CPU fan
9	leds-2
10	Multi mobile charger cable
11	DC motor
12	Power supply-2
13	Adapter 12v 2amp
14	Potentiometer
15	Slide switch
16	Battery 12v
17	DC Pump
18	Female power jack
19	Connectors-25

Table:3:SOFTWARE COMPONENTS

S.NO	SOFTWARE COMPONENTS
1.	Arduino IDE
2.	Embedded C

Arduino Uno is a very valuable addition in the electronics that consists of USB interface, 14 digital I/O pins, 6 analog pins, and Atmega328 microcontroller. It also supports serial communication using Tx and Rx pins.

There are many versions of Arduino boards introduced in the market like Arduino Uno, Arduino Due, Arduino Leonardo, Arduino Mega, however, most common versions are Arduino Uno and Arduino Mega. If you are planning to create a project relating to digital electronics, embedded system, robotics, or IoT, then using Arduino Uno would be the best, easy and most economical option..

Table:4:Arduino UNO Technical Specifications

Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (0.5 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz

VI. WORKING PRINCIPLE

Current Sensor detects the current in a wire or conductor and generates a signal proportional to the detected current either in the form of analog voltage or digital output.

Current Sensing is done in two ways – Direct sensing and Indirect Sensing. In Direct sensing, to detect current, Ohm's law is used to measure the voltage drop occurred in a wire when current flows through it.

A current-carrying conductor also gives rise to a magnetic field in its surrounding. In Indirect Sensing, the current is measured by calculating this magnetic field by applying either Faraday's law or Ampere law. Here either a Transformer or Hall effect sensor or fiberoptic current sensor are used to sense the magnetic field.

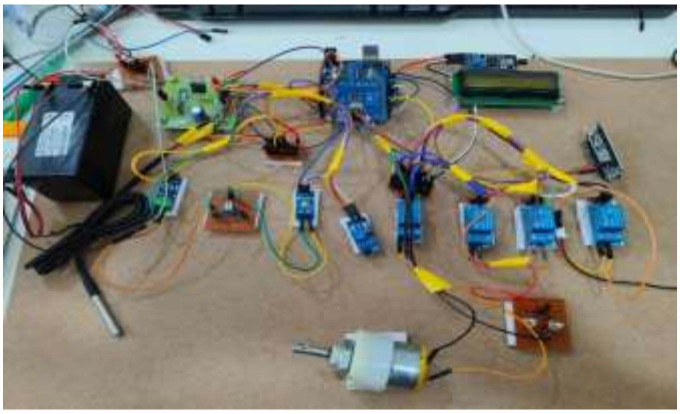
ACS712 Current Sensor uses Indirect Sensing method to calculate the current. To sense current a liner, low-offset Hall sensor circuit is used in this IC. This sensor is located at the surface of the IC on a copper conduction path. When current flows through this copper conduction path it generates a magnetic field which is sensed by the Hall effect sensor. A voltage proportional to the sensed magnetic field is generated by the Hall sensor, which is used to measure current.

The proximity of the magnetic signal to the Hall sensor decides the accuracy of the device. Nearer the magnetic signal higher the accuracy. ACS712 Current Sensor is available as a small, surface mount SOIC8 package. In this IC current flows from Pin-1 and Pin-2 to Pin-3 and Pin4. This forms the conduction path where the current is sensed. Implementation of this IC is very easy.

ACS712 can be used in applications requiring electrical isolation as the terminals of the conduction path are electrically isolated from the IC leads. Thus, this IC doesn't require any other isolation techniques. This IC requires a supply voltage of 5V. Its output voltage is proportional to AC or DC current. ACS712 has a nearly zero magnetic hysteresis.

Where Pin-1 to Pin-4 forms the conduction path, Pin-5 is the signal ground pin. Pin-6 is the FILTER pin that is used by an external capacitor to set the bandwidth. Pin-7 is the analog output pin. Pin-8 is the power supply pin.

VII. REAL-TIME PHOTOGRAPHY



VIII. OUTPUT / RESULTS

IX.THINGSPEAK OUTPUT GRAPH ANALYSIS

Fig. 1: VOLTAGE ANALYSIS

Fig. 2: CURRENT ANALYSIS

Fig. 3: TEMPERATURE ANALYSIS

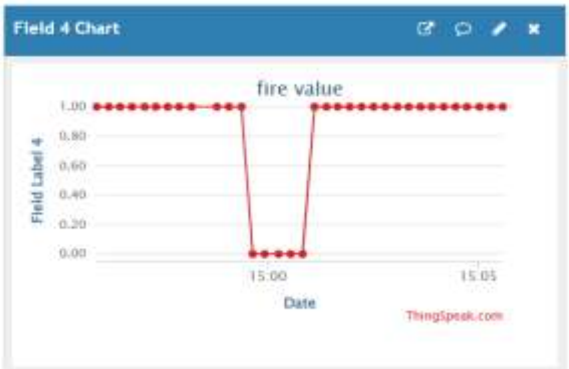


Fig. 4: FIRE VALUE ANALYSIS

Fig. 5: LAMP INDICATOR

X.CONCLUSION

This review paper briefly explains the study of Battery Management System of an Electric Vehicle by considering several parameters which are important for monitoring and taken into consideration to avoid explosion of Li-Ion Battery Cells. Several papers are reviewed to understand the behaviour of Li-Ion battery, technology used for gathering information through IoT, etc. Moreover, this paper has investigated about

IoT technology that can be used for monitoring purpose of age. The information or data we receive through

different sensors is used for monitoring purpose and protecting our battery from being destroyed. It also helps to increase the life of the battery and makes it reliable to use for the Electric Vehicle.

The IoT-Based Electric Vehicle Battery Management System with Charge Monitoring and Fire Protection provides an effective solution for improving battery safety, performance, and reliability in electric vehicles. The system continuously monitors important battery parameters such as voltage, current, and temperature to ensure safe operating conditions. Integration of IoT technology enables real-time data transmission and remote monitoring through the ThingSpeak platform, allowing users to analyze battery performance and take preventive actions. The inclusion of fire detection and automatic thermal management enhances system safety by activating cooling mechanisms and isolating the battery during abnormal conditions. User-controlled adjustments further increase system flexibility and operational control. The prototype successfully demonstrates efficient energy monitoring, hazard prevention, and smart battery supervision. Overall, the proposed system offers a scalable, cost-effective, and intelligent approach for modern EV battery management applications.

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