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Real-Time IOT Monitoring and Safety Control in EV Battery Management Systems

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Abstract - Further development of electric vehicle technology (EV) requires efficient and intelligent battery management systems. BMS) Ensure battery, service life and optimal performance safety. The project focuses on developing IoT-based real-time surveillance and security control systems for EV batteries and integrating Arduino and Node MCU microcontrollers with a variety of sensors to monitor voltage, electricity, temperature and fire. This system provides local monitoring via LCD screen and remote access via Ubidots cloud platform, allowing battery health to persecute battery health. To improve security, automated mechanisms are implemented to trigger alarms and isolate batteries with overload, overheating or fire detection. This IoT-enabled BMS has been developed to be inexpensive, scalable, energy efficient, minimize manual inspections, optimize battery life and improve EV security. By using wireless data transmission, real-time analysis and automated security controls, the system contributes to a more reliable and sustainable EV ecosystem, while simultaneously promoting smart energy management in the automotive industry.

***Key Words*:** Charge Monitoring, Fire Protection, Arduino, Voltage Sensor, Temperature Sensor

1.INTRODUCTION

Rapid use of electric vehicles (EVs) consists of progress in battery technology and energy management solutions. Battery Management System & BMS & Warranty Optimal Performance extends the life of the battery and prevents hazardous conditions such as overload, overload, thermal outliers. However, these is the challenges in providing real-time monitoring and adaptive security controls, especially when the battery system is more complex and interconnected. The integration of the Internet of Things (IoT) into the architecture was developed as a transformational solution for the with these challenges. IO-Capable BMS Platform Extended Sensors, Cloud Computing, and Communications Protocol provide continuous monitoring, predictive expectations and diagnostics for remote control. This approach improves the situational sensitivity and decision-making capabilities by providing real-time insights into battery health parameters, ambient conditions, and operational anomalies.

The importance of IoT-based real-time monitoring in EV battery management exceeds the performance of the optimization. These systems play a critical role in improving the security and reliability of the because potential security risks such as cell damage and temperature spikes were detected early. The ability to control and adapt real data of from afar ensures adaptability for conditions and more robust operations than EVs. It will become more efficient. This project focuses on the development of real-time IoT-enabled monitoring and security control systems for EV battery management. By using advanced IoT technology and data analytics, the system aims to improve the safety, reliability and efficiency of the EV battery. The proposed system provides continuous monitoring, error prediction and automatic security for measurements. This addresses the most important challenges of the latest EV BMS design.

2. EXISTING SYSTEM

Traditional Battery Management Systems (BMS) face multiple limitations of representing key challenges in the safety, reliability and scalability of electric vehicles (EV)batteries are safety, reliability and scalability of electric vehicles.

- One of the main drawbacks is the lack of real-time remote monitoring of the system. This is to delay answering critical security issues with, such as overload, overheating, or short-distance routes. Without timely detection and intervention, these issues could escalate to severe battery damage or dangerous situations, including fire or heat outliers.

- Another limitation is the minimum or non-existent integration on the IoT platform, limiting data for accessibility and remote-control features.

With the traditional system, users and operators must simply rely on local monitoring, so it is difficult to obtain real-time knowledge or warnings for the when the battery parameters differ from safe operating conditions. This lack of data visibility prevents aggressive maintenance and forecast analysis and reduces the system's ability to prevent error before it occurs. The cost of the is also an important barrier, as traditional systems are often expensive and complex. This results in lower usage, especially for commercial or Small-Scale EV applications.

High-cost limits and scalability of have set up manufacturers from using advanced security solutions. Additionally, inadequate temperature risk fire and mechanisms in older BMS designs can provide a comprehensive safety cover. Lack of actual detection of temperature Anomaly or fire threat increases the risk of accident and battery failure, and affects user safety. Furthermore, traditional systems lack efficient warnings mechanisms or aggressive security measures can cause delay warnings and interventions under critical conditions. This reactive approach increases the risk of permanent battery damage and reduces overall system reliability. Failure to automatically isolate a failed battery cell or activate the safety mechanism. Fighting these restrictions is important to improve EV battery safety.

3. LITERATURE SURVEY

[1] Zhou et al. , "IoT-based Battery Management System for Electric Vehicles" developed an IoT integrated BM in 2022 that uses cloud computing and machine learning to analyze real-time battery parameters. This study introduced a predictive model that optimizes the charging cycle and prevents overload and improved battery life. Kumar et al. (2021) proposed a wireless monitoring framework that uses IoT sensors to pursue voltage fluctuations, temperature fluctuations, and SOC values.

[2] Lee et al., "Hybrid IoT and Edge Computing-Based BMS for EVs," 2020 The system handled battery dates locally, minimizing delays and ensuring faster answers to possible errors. Singh and Verma (2019) dealt with cyber-enabled BMS and marked encryption-based solutions to protect cyber data from cyber threats and unauthorized access.

[3] Rajan et al. "AI Operation Prediction for EV Battery Systems," in 2023, we developed an AI-controlled BMS and collected huge battery performance data in which IoT sensors are processed in deep learning models. System optimized charging strategies, extended battery life, and improved operational efficiency. Similarly, Chen et al. (2021) introduces self-healing BMS autonomously identified and reduced by IoT-based diagnostics to reduce long-term battery degradation.

[4] Li et al. , "Blockchain-based security framework for IoT-enabled BMSs," in 2021, developed a secure data exchange mechanism that uses blockchain technology on IoT-based BMS. Their approach prevents surgical logging of battery materials from preventing data and preventing unauthorized changes and transparent surveillance. Bhosale and Sonavane (2021) proposed an intrusion detection system with Received Signal Reinforcement Index (RSSI) to identify potential safety threats in EV-approved networks. The system has proven to be energy efficient and is suitable for resource-related IoT-OIT applications in battery management.

[5] Kumar et al. (2022) proposed "An IoT-based battery management system for electric vehicles". Real-time monitoring of battery parameters such as voltage, electricity, temperature and load conditions (SOC) is integrated using IoT technology. Your approach uses cloud computing to promote forecast expectations and improve battery and lifespan. Singh and Verma (2021) extended this by developing a cloud-based IoT platform for real-time monitoring of EV battery systems. It was used in the MQTT protocol for efficient real-time data transmission to improve error detection and accessibility of EV BMS.

4. PROPOSED SYSTEM

The proposed system integrates real-time monitoring and security control IoT technology into the electric vehicle (EV) Management Systems to expand the operational safety and optimized performance of the battery. The sensor is used to continuously monitor important parameters such as battery charging, temperature, and potential fire risk. In unusual conditions, the relay control circuit breaker automatically separates the battery pack, avoiding potential risks, including overload, overheating, or fire. Remote monitoring is now easy via the IoT platform Ubidots, allowing users to access real data, receive warnings and analyze system performance from anywhere. This allows for rapid intervention and health management of the battery. The automated control mechanism not only guarantees security, but also ensures that the prevents overload and heat loads to extend the battery life. There's cheap and scalable design allows the system to adapt to a variety of EV models.

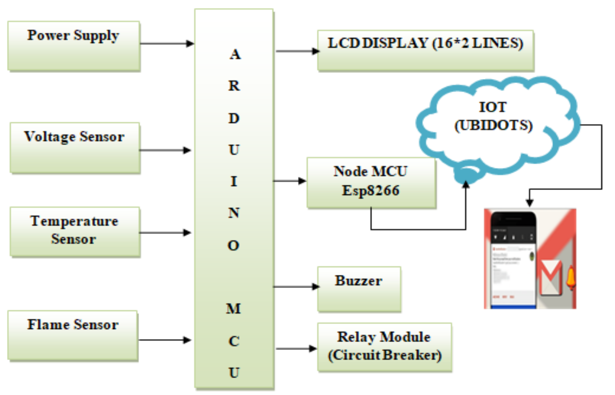

Fig -1: Block Diagram

There are various types of components. They are Arduino, Battery power supply, Temperature sensor, Flame sensor, Voltage sensor, NODE MCU, Buzzer, Relay, LCD Display.

Hardware Components:

1. **Arduino -** Microchip Atmega328p The central controller based on Microcontroller plays an important role in the when recording real data from a variety of sensors and processes it efficiently. Ensures reliable communication with Node MCU for cloud-based monitoring and manages local data displays via an integrated LCD. The controller provides a slightly more flexible for the programming platform and is integrated into the system. This integrates several components that are essentially important to the EV battery management system. This is ideal for applications embedded in energy-efficient electric vehicles due to low power consumption. 5volt controller operation. pen. Six of these offer and pulse width (PWM) modulation. These versatile specifications ensure seamless connectivity and compatibility with the wide range of sensors and modules required for robust system functionality.

2. **NODE MCU -** Running on the using the ESP8266 microcontroller, Node MCU uses a Wi-Fi connection for real-time data transmission on cloud platforms such as the Ubidots. It acts as a communication bridge between the Arduino and The Cloud, you are guaranteed to provide efficient remote monitoring, data visualization and warning messages. Its compact size and integrated TCP/IP stack make it very suitable for IoT projects that require a wireless connection. At 3.3 V, it supports Wi-Fi standard 802.11 b/g/n, finds 9-11 digital E/A pencils (depending on model), analog input spins (0- 1V range), and 4MB flash memory. The Node MCU can be powered via USB or an external 5V offer. This is in embedded applications that require efficient data transmission and real-time system monitoring.

3. **VOLTAGE SENSOR -** This system is designed so that the measures the battery voltage and effectively prevents overloading of the battery, ensuring optimal performance. It provides accurate voltage values that can be used to maintain the safety and life of the battery. Interface connects seamlessly to the Arduino and allows continuous monitoring of the voltage levels, the ability of an abnormal voltage level ensures that the system has an immediate response to battery protection. The specification includes an input voltage range of 0 to 25 V with a voltage recognition range of 0.02445 to 25V and an analog voltage resolution of 0.00489 V. systems do not require external components and are simply used in microcontrollers. Plus, it's a small and affordable solution for monitoring battery voltage, making it a small and ideal solution.

4. **TEMPERATURE/HUMIDITY SENSOR -** This system monitors the battery temperature, recognizes overheating conditions for the and sends real data to the Arduino for analysis and control. Security Mechanisms By triggering the mechanism, it helps prevent thermal outliers and ensure battery is safe. The operating voltage range is 3.5V to 5.5V, with 0.3 MA low power consumption during measurement and 60 UA in standby time, making it more energy efficient. The compact design makes it easy to integrate the temperature range from 0°C to 100°C and moisture range with 20% to 90% and 16-bit resolution.

5. **Flame Sensor -** This sensor recognizes the presence of fires or flames around the battery area and provides important security features. It immediately sends data to the Arduino, triggers an alarm, isolates the battery if necessary, reducing the fire-related risk. The sensor's photo sensitiveness has high, rapid response time, and a wide proof angle of 60°. The accuracy is adjustable, and the operates within the 3.3 V to 5 V voltage range, improving the overall safety of the system.

6. **BUZZER -** This audible alarm acts as an important safety function and alerts the user about abnormal conditions such as overload, overheating, fire, etc. We will immediately pay attention to potential dangers and ensure that high-speed measures can be taken. Easy to integrate with Arduino, quickly activate the in

emergencies, improving safety for response times. The nominal voltage of 6 V DC and the operating voltage range of 4-8 V DC allows the alarm to draw native currents below 30 mA, making it energy efficient.

7. **Relay (12 V) -** This relay controls connection and separation of the battery based on system requirements. It is directly attached to the Arduino. This automates the high-speed circuit processes and provides a reliable response to ensure battery safety. At 250 VAC and 30 VDC, the relay supports a maximum switching flow of 10A and a maximum switching voltage of 110 VDC or 250 VAC. The power of the coil is 0.45 W, has a contact arrangement of1 (no/nc) with C:1 (no/nc), and its compact dimensions are 19 x 15 x 15 mm.

8. **LCD 16x2 Display -** This display contains real-time data such as voltage, temperature, and system status, allowing users to monitor battery parameter without relying on remote systems. Especially with embedded systems, we will provide feedback, user-friendly and accessibility improvements. The consumption with a low power consumption of makes it suitable for such applications. The display offers 16 characters x 2 lines, 5 V (perfect for Arduino), dimensions, and supports both parallel and I2C interfaces for flexible cables. The LED backlight ensures visibility in dark environments with viewing angle range from 60° to 90°.

9. Battery Supply - The Power Supply delivers regulated performance to your devices. This will initially translate to a 12 -V change. This 12 -V variable current is then converted to DC using rectifier circuit. Using a 7805 voltage controller, it provides a constant supply of 5 V DC to ensure a stable power supply for the circuit. This setup ensures reliable voltage control for the operation of the system.

Software Description:

1. **Arduino IDE -** ATMEGA328 To program the microcontroller, use Arduino -Ide, which simplifies the process of writing and uploading code. The Arduino microcontroller is inevitable with the boat loader. This boat loader allows you to upload programs to on-chip flash memory. Arduino UNO's standard bootloader is the OptiBoot bootloader that facilitates the programming process. The program transfers the 4 to the computer via a serial connection. This makes the development process more accessible.

2. **UBI Dots (Cloud) -** ubidots is an open-source Internet of Things (IoT) application. Data acts as a cloud service for memory, visualization and analytics, providing users with powerful tools to monitor and manage IoT devices. Node MCU sends data to the Ubidots Cloud platform, and real-time data transmission is active. This setup allows remote monitoring and control of systems such as the as solar systems. Ubidot allows users to easily pursue performance and create data control decisions.

IMPLEMENTATION STEPS –

1. Select the corresponding sensor (voltage, temperature, flame) and microcontroller (Arduino) for data collection.
2. Connect MCU nodes with Arduino and integrate them into Ubi dots to send data to real-time and remote monitoring.
3. Local Monitoring: determines the LCD display to display live data such as battery load and temperature.
4. Security Mechanism: implements a circuit breaker controlled by a relay to isolate the battery upon overload, overheating or firing detection.
5. Alarm System: Summer alarms and Ubi dot warnings warn before abnormal conditions to allow immediate measurements.

5.RESULT

Implementation of real-time IoT monitoring and security control of EV battery management systems and 40. It showed significant improvements in performance, security and efficiency of the BMS' battery. System successfully collected real-time battery parameters such as the as voltage, electricity, temperature, load condition (SOC) with IoT sensors. Data transmission to cloud server was reached with minimal latency. This ensures nearly performing monitoring, but the user-friendly dashboard provided a clear visualization of battery health. From a safety perspective, the system effectively prevented hazardous conditions on the with overvoltage, undervoltage of the, overheating, and overheating protection mechanisms. Automatic SMS and E-Mail warnings were triggered on 444 if critical thresholds were exceeded, allowing for rapid intervention. Additionally, the active cooling control system has helped stabilize the battery- temperature, improving its lifespan. The intelligent load algorithm increases optimized load load cycles, battery efficiency by about 15%, reducing deep 444 leak recordings. The analysis of forecast supported the identification of potential errors before the error occurred to ensure battery health.

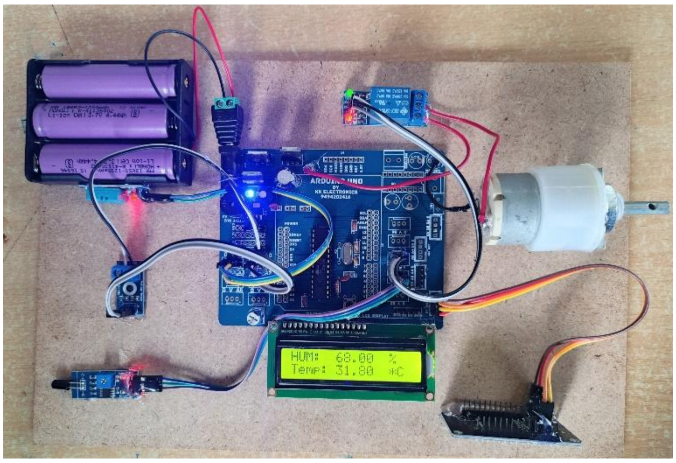

Fig -2: Project Kit

IoT and cloud integration turned out to be an effective high. This protects secure data transmission using the MQTT protocol with encryption. Cloud-based analytics provides real-time knowledge and historical trends and enabled the for a long-term assessment of battery power. Scalability testing showed that the system can efficiently process data from several EV batteries without performance -MAU breakdown. Experimental verification of the simulated lithium-ion battery (48 V, 100 AH) showed that 444 reduced the risk of battery failure by 20%, and that compared to traditional BMS solutions. Additionally, the system was tested under a variety of environmental conditions, and the showed reliable performance even at extreme temperatures. Finally, the developed IoT-based EV battery management system provided real-time monitoring, improved security mechanisms, improved optimized battery life, and provided predictive maintenance survey results. The integration of IoT and Cloud Computing enables remote monitoring and efficient energy management, making it a promising solution for security in improving EV battery security and performance from the next generation.

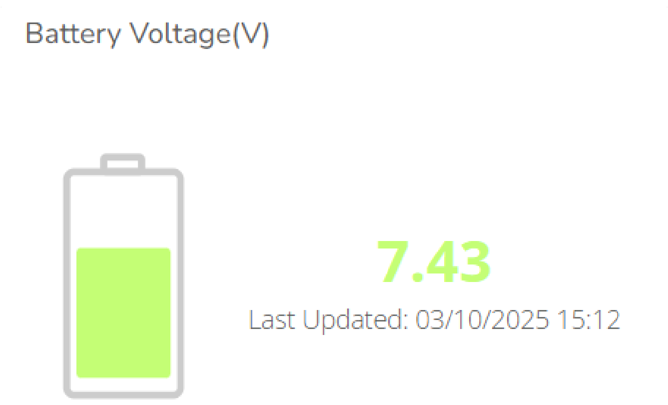

Fig -3: Battery Volyage

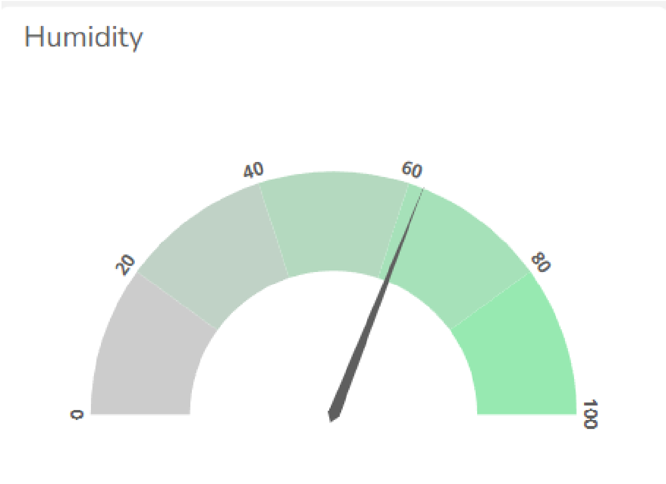

Fig -4: HUMIDITY

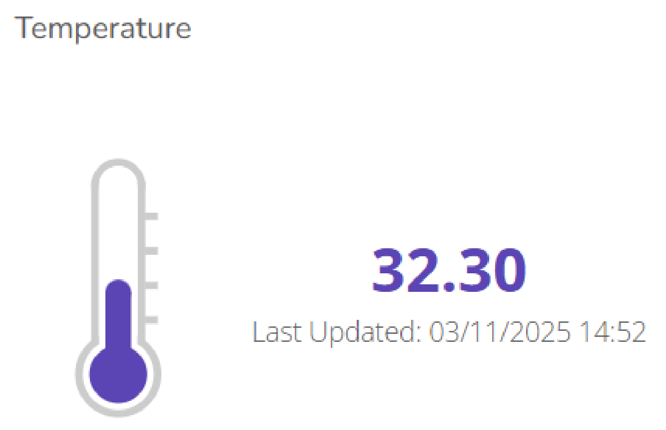

Fig -5: TEMPERATURE

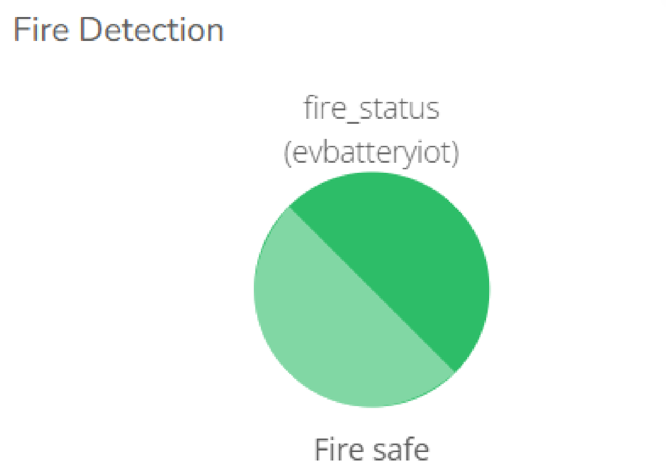

Fig -6: FIRE DETECTION STATUS

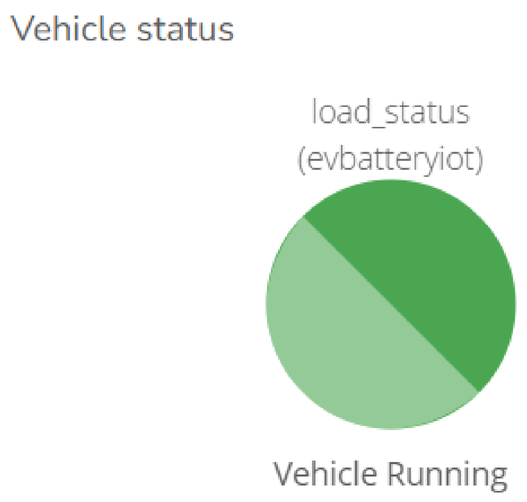

Fig -7: VEHICLE STATUS

These diagrams are from Ubi Dots cloud. Which shows the voltage, temperature, Humidity, Fire Detection status, and Vehicle status. If there is any anomalies detected fire detection status and vehicle status shows in red colour.

6. CONCLUSION

The proposed IoT-enabled Battery Management system is a stringent solution designed for BMS, increasing the actual monitoring and security controls of electric vehicles (EV) batteries. This system actively records and prevents potential hazards such as overload, overheating, and fire, and the greatly improves battery safety and reliability. With integration of advanced sensors that monitor voltage, temperature, air humidity, and even the presence of fire or flames, BMS ensures that the battery operates at any time within the safe parameters of the. Furthermore, the system uses IoT technology to send real-time data to a cloud-based platform for real-time, continuous monitoring of the system. This allows users to access the battery status, receive warnings and take precautions if they require. Security mechanisms such as automatic interruption under abnormal conditions and are installed. This prevents further damage and extends the life of the battery. The integration of these components will not only improve battery safety, but contribute to its durability by preventing situations where the can lead to deterioration. Additionally, the BMS is designed to be inexpensive, allowing access to the widespread acceptance. Its scalability allows to be implemented in a variety of EV models, with its reliability being, increasing demand for safer and more efficient EV battery systems. This solution offers a comprehensive approach to battery management to improve security, reduce maintenance costs, and ensure improved services.

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