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EV Based BMS with Charge Monitoring, Fire Protection and Accident Detection

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Abstract: *Electric Vehicle (EV) Battery Management System (BMS) plays a critical role in ensuring safe and efficient vehicle operation. This project focuses on developing an advanced BMS that integrates real-time charge monitoring, fire protection, and accident detection features. The system continuously measures battery voltage, current, temperature, to maintain optimal performance and extend battery life. A smart thermal protection unit detects overheating and fireprevention actions. Additionally, an accident detection module uses sensors to sense sudden impacts . The proposed system enhances safety, reliability, and overall vehicle protection by combining monitoring, fault detection, and emergency response through this project.*

Keywords: Battery Management System, Charge Monitoring, Fire Protection, Accident Detection, Electric Vehicle Safety

I. INTRODUCTION

Electric Vehicles depend on high-capacity lithium-ion batteries, which require continuous supervision for safe and efficient operation. A Battery Management System (BMS) equipped with charge monitoring, fire protection, and accident detection plays a crucial role in maintaining battery health and vehicle safety. The charge monitor tracks voltage to prevent overcharging or deep discharge. Fire protection features actively monitor temperature rise and detect abnormal conditions to avoid thermal runaway. Accident detection sensors identify sudden impacts and instantly disconnect the battery to prevent short circuits or fire hazards. Together, these functions make the EV safer, more reliable, and better protected during daily use as well as emergency situations.

II. PROBLEM STATEMENT

Electric Vehicles rely on large battery packs that are vulnerable to issues such as overcharging, overheating, and physical damage during accidents. These conditions can lead to reduced battery life, unexpected failures, or even fire hazards. However, most conventional BMS systems do not provide combined real-time charge monitoring, early fire detection, and immediate accident response in a single integrated unit. Therefore, there is a need for a smart Battery Management System that can continuously monitor the battery's charge level, detect fire-related temperature rise, and identify accidents instantly to isolate the battery and prevent damage. This project aims to develop a reliable and safety-focused EV BMS that enhances protection, efficiency, and user safety.

III. LITERATURE REVIEW

Recent studies on Electric Vehicle Battery Management Systems highlight the growing importance of advanced safety features beyond basic monitoring. Research on thermal safety shows that lithium-ion batteries are highly sensitive to overheating, and several works emphasize the need for thermal-runaway detection using temperature, voltage, and accident detection . Existing reviews also discuss multiple fire-protection strategies, including thermal barriers, reduce fire propagation faults. However, designs that combine thermal monitoring, fire prevention, and crash response in a single BMS framework.

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Overall, the literature suggests a strong need for unified safety-focused BMS architectures that can detect faults quickly, isolate the battery during accidents, and minimize fire risks through intelligent thermal management.

IV. RESEARCH METHODOLOGY

The methodology for developing the enhanced EV Battery Management System (BMS) followed a systematic approach involving requirement analysis, hardware design, algorithm development, and performance evaluation. The study began by identifying key safety needs for EV battery packs, with emphasis on real-time voltage monitoring, temperature-based fire protection, and vibration/impact-based accident detection. These requirements guided the design of the system architecture.

In the implementation stage, appropriate sensors were selected and interfaced with a microcontroller. Voltage sensors were used to monitor abnormal over-voltage or under-voltage conditions, while temperature sensors were employed both for thermal management and early fire-risk detection. A vibration sensor was integrated to detect sudden shocks or collisions that may cause battery damage. The control logic was developed to continuously read sensor values, compare them with predefined safety thresholds, and protective actions. System validation involved conducting controlled tests that simulated overheating, voltage irregularities, and mechanical vibrations representing accidental impact. Data from each test scenario were analyzed to evaluate detection accuracy, response time, and reliability of the protection mechanisms. The findings helped refine threshold values and improve the stability of the integrated safety system.

V. WORKING

The system is designed around an Arduino microcontroller, which acts as the central unit responsible for monitoring battery conditions, detecting hazards, and activating safety responses. The battery supplies power to the Arduino, sensors, and connected modules. A TP4056 charging circuit ensures safe charging of the battery and provides regulated input to the controller. For safety monitoring, the Arduino receives real-time data from two critical sensors: the temperature sensor, which detects overheating and possible fire-risk conditions, and the tilt/vibration sensor, which identifies sudden shocks, tilting, or accidental impacts. These sensor readings are continuously compared with predefined threshold values in the control program .When an abnormal condition is detected, the Arduino activates the appropriate relay. One relay is used for electrical isolation or emergency shutdown, while another relay drives the fire extinguisher mechanism, enabling automatic fire suppression in case of high-temperature events.

A GPS module connected to the Arduino provides location tracking, which becomes essential during accidents or emergency situations. The system also includes a Node MCU module, which sends sensor data, alerts, and location details to a cloud-connected server. The server stores all information in a database and can display real-time updates through the cloud system. This allows remote monitoring of battery status, accident alerts, and fire warnings from any internetconnected device.

Overall, the integrated setup ensures continuous monitoring, immediate hazard detection, automatic safety actions, and cloud-based reporting, making the system suitable for smart and safe electric-vehicle battery protection.

WORKING PRINCIPLE

STEP 1 : Battery powers the Arduino and all sensors in the system.

STEP 2 : The temperature sensor continuously checks for overheating or fire risk. **STEP 3:** The tilt/vibration sensor detects sudden shocks or accident-like movement **STEP 4:** Arduino reads these sensor values and compares them with safety limits.

STEP 5: If high temperature is detected, Arduino activates the relay to turn on the fire extinguisher.

STEP 6: If vibration/impact is detected, it triggers an accident alert signal.

STEP 7: The GPS module provides the location of the vehicle during emergencies.

STEP 8 : Node MCU sends data (temperature, accident alerts, location) to the cloud server. **STEP 9:** The server stores the data in the database and allows remote monitoring.

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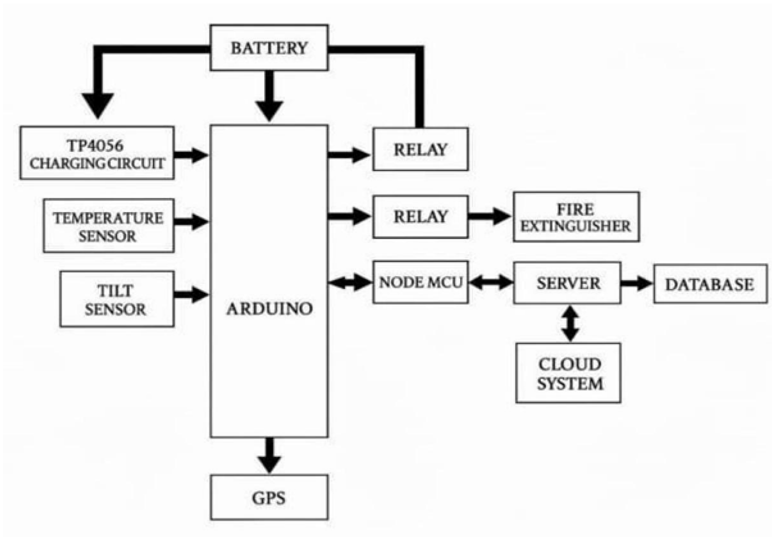
VI. BLOCK DIAGRAM



COMPONENTS USED

- Battery
- TP4056 Charging Circuit
- Arduino Microcontroller
- Temperature Sensor
- Tilt/Vibration Sensor
- GPS Module
- Node MCU (Wi-Fi Module)
- Relay Modules
- Fire Extinguisher Unit
- Server and Cloud System
- Database

VII. COMPONENT DESCRIPTION

- **Battery:** Provides power to the vehicle and all connected components, ensuring the EV operates smoothly.
- **TP4056 Charging Circuit:** Manages safe charging of the battery, preventing overcharging, overheating, and extending battery life.
- **Arduino Microcontroller:** Acts as the brain of the system, processing data from sensors and controlling outputs like relays, alarms, and the fire extinguisher.
- **Temperature Sensor:** Monitors battery and system temperature to prevent overheating and thermal hazards.
- **Tilt/Vibration Sensor:** Detects sudden tilts or shocks, helping identify accidents or abnormal movement.
- **GPS Module:** Tracks the real-time location of the vehicle for navigation and emergency response.
- **Node MCU (Wi-Fi Module):** Provides wireless connectivity, sending data to the cloud or server for remote monitoring.
- **Relay Modules:** Serve as electronic switches controlled by the microcontroller to operate high-power devices safely.

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- **Fire Extinguisher Unit:** Suppresses fire in battery or vehicle emergencies, activated automatically or manually.
- **Server and Cloud System:** Stores and processes data from the vehicle, enabling remote monitoring and alert generation.

VIII. ADVANTAGES

- **Battery Protection:** Monitors voltage and temperature to prevent overcharging, undercharging, and overheating, increasing battery life.
- **Accident Detection:** Tilt and vibration sensors detect shocks or collisions, improving vehicle safety.
- **Fire Safety:** The integrated fire extinguisher unit provides immediate protection against battery or vehicle fires.
- **Remote Monitoring:** Node MCU and GPS modules enable real-time tracking and remote monitoring through the cloud/server.
- **Data Logging:** Sensor data is stored in the database for analysis, trend detection, and historical reference.
- **Efficient Control:** Relays and the microcontroller ensure safe and efficient operation of all connected devices.
- **Enhanced Reliability:** Continuous monitoring of all critical parameters improves the overall reliability and safety of the EV system.

IX. LIMITATIONS

- **High Initial Cost:** Integration of multiple sensors, microcontroller, Wi-Fi module, and fire extinguisher increases the system cost.
- **Complexity:** Managing data from multiple sensors and modules requires careful design and programming.
- **Maintenance:** Sensors and modules may require periodic calibration and maintenance to ensure accuracy.
- **Connectivity Dependence:** Remote monitoring relies on Wi-Fi or internet availability, which may not always be consistent.
- **Limited Coverage:** GPS and cloud features may not function properly in areas with poor network or satellite reception.
- **Power Consumption:** Continuous operation of sensors, Wi-Fi module, and microcontroller consumes additional battery power.

X. CONCLUSION

The EV BMS system is a comprehensive solution for monitoring, protecting, and ensuring the safety of electric vehicles. By integrating voltage and temperature sensors, tilt/vibration detection, GPS tracking, Wi-Fi connectivity, and a fire extinguisher unit, the system provides real-time monitoring, accident detection, and fire safety. The use of a microcontroller and relay modules ensures efficient control of all components, while cloud connectivity and database storage enable remote monitoring and data analysis. Although the system has some limitations like cost, complexity, and power consumption, its advantages in enhancing battery life, vehicle safety, and reliability make it an essential feature for modern electric vehicles.

XI. FUTURE SCOPE

The EV BMS system can be further enhanced by integrating advanced features such IoT-based real-time ana management. Additional sensors like smoke, gas, and current sensors can improve safety and fault detection. Cloud connectivity can be upgraded for mobile app-based monitoring and emergency alerts. With these improvements, the system can evolve into a fully intelligent and autonomous battery management and vehicle safety solution.

REFERENCES

[1]. M. Gopstein, "Energy storage the grid from characteristics to impact, Proc .IEEE, vol. 100, no. 2, pp. 311–316, Feb. 2012.

[2]. M. Beaudin, H. Zarei pour, A. Schellenberglabe, and W. Rose hart, "Energy storage for mitigating the variability of renewable electricity sources: An updated review, Energy Sustain. Develop., vol. 14, pp. 302–314, Dec. 2010.

[3]. ssJ. Cao, N. Schofield, and A. Emadi, "Battery balancing methods: A comprehensive review, Vehicle Power and Propulsion Conference, 2008. VPPC '08. IEEE, pp. 1–6, 35 Sept 2008.

[4]. M. Uno and K. Tanaka, "Influence of High-Frequency Charge-Discharge Cycling Induced by Cell Voltage Equalizers on the Life Performance of Lithium-Ion Cells, Vehicular Technology, IEEE Transactions on, vol. 60, pp. 1505–1515, 2011."

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