EV BMS WITH CHARGE MONITOR AND FIRE PROTECTION

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Abstract:
Battery storage is the most important part of any electric bus or vehicle (EV) and it stores the necessary energy for the operation of an electrical vehicle. To prize the maximum affair of a battery and to ensure its safe operations it's necessary. BMS (battery operation system) exactly works spectators all Parameters and gives necessary services to ensure the safe operation of the battery. Hence battery operation system forms an integral part of any electrical vehicle and Safety is handed to both the user and the battery by icing that it operates within its safe operating parameters. The given system only monitors the battery parameters and charges it safely and also protects it to avoid any damage or accidents. The given model has the following functions current dimension, voltage dimension, protection, battery status discovery on television, and charge battery safely, etc.

Electric vehicles are buses powered by one or farther electrical motors, which draw energy from rechargeable batteries rather of counting solely on internal combustion machines that consume reactionary powers. A Battery Management System is a critical part of electric vehicles and other battery- powered systems. It monitors and controls the operation of the battery pack, icing its optimal performance and safety.

1. INTRODUCTION

1.1 ELECTRIC VEHICLE

Electric vehicle (EV) is one that is made to run by an electric motor rather than an internal-combustion engine (IC). It generates energy by burning a mixture of Petroleum and its other products. Due to Which , these vehicle are found out to be a one of the replacement for current-generation of vehicles in order to address challenges such as rising pollution, global warming, and natural resource depletion. Electrical vehicles are

attracting customers due to its environment-friendly nature as it does not have an internal-combustion engine which creates harmful gases for the planet, also they have less cost of maintenance and they are potential to a tax credit as the customer is cutting down the impact on the environment by choosing a zero-emission system. Countries like the United States, China and Japan had updated its policies and standards to support the development of EVs.

1.2 History of Electric Vehicles

Electric vehicles, which run on batteries rather than gas engines, are becoming more common. Electric vehicles are preferred by those who want to safeguard the environment and maybe go greener. However, many people are astonished to hear that electric vehicles are not a new technology. While it is unclear who invented the first electric car, electric motors were clearly in use as early as the 1800s. Around 1828, Anyos Jedlik invented the very first electric motor [1]. Using a small electric engine, he developed a self-moving tiny model automobile. A bigger electric motor designed by Scottish inventor Robert Anderson has been used to run a carriage between 1832 and 1839.

American innovators returned to the electric car in the 20th century. William Morrison created what many consider to be the first practical electric car around this period, however it lacked range. During this period, hybrid vehicles were also developed to address a variety of concerns with electric vehicles.

Electric vehicles in the entire history have never been so in news, and a lot of them can drive many miles just by charging only once. In 2008, Tesla introduced the Roadster. Due to many hindrance and faults, it was being able to travel which was more than 200 km just by charging once. It was quickly followed by the Mitsubishi kilometer in Japan. The creation and introduction of these two cars, particularly Tesla, signaled the start of the modern era of electric vehicles. Other major automakers rapidly followed behind, developing evs of their own. A vast number of people had already created hybrids, suggesting that the method was well-established. The Chevrolet Volt was made by General Motors, and the Nissan Leaf was presented by Nissan. Smaller companies, such as Tesla, are pushing significant advancements in electric vehicles.

An electric car can be purchased for a variety of reasons. The motors are whisper quiet, and the trip is wonderfully relaxing. Since the power is sent directly to the wheels, the torque is higher than most people believe. There’s no need to stop at a gas station, and while drivers must pay for the electricity needed to charge the car, it’s less expensive than gasoline.

2. LITERATURE SURVEY

1. **Thermal Management and Fire Safety in EV Battery Systems,** S. Wang, Y. Zhao, and P. Chen, 2024, Springer) This paper presents an in-depth study on how thermal management strategies can significantly reduce fire risks in EV battery systems. It emphasizes advanced cooling mechanisms and early fire detection technologies.
2. **A Novel Battery Management System Design with Fire Protection for Electric Vehicles** (L. Chen, Y. Wu, and X. Zhang, 2023, IEEE) The authors propose a new BMS architecture incorporating real-time temperature monitoring and automatic isolation of faulty cells to enhance fire safety and system reliability.
3. **Electric Vehicle Battery Thermal Management and Fire Safety** (M. M. A. Khan and P. Dutta, 2022, MDPI) This study evaluates various thermal management methods including phase-change materials and active cooling systems. It also explores fire suppression techniques tailored for EV applications.
4. **Design and Implementation of a Battery Management System with Fire Protection in EVs** Z. Wei, Y. Liu, and P. Chen, 2021, IEEE) The paper highlights practical implementation aspects of integrating fire protection mechanisms into BMS, such as sensor placement and fault response algorithms.
5. **A New Approach to Fault Detection and Charge Balancing in EV BMS** (F. Zhang, X. Zhang, and H. Chen, 2020, IEEE) This earlier work lays the groundwork for safe BMS design through improved fault detection, charge balancing, and fault isolation, indirectly contributing to fire safety

3. METHODOLOGY

3.1 Block Diagram

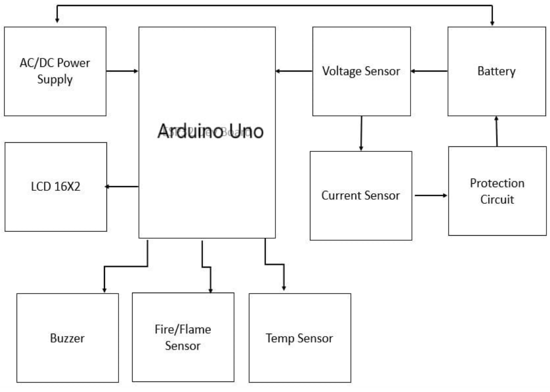


Fig. Block Diagram

Sensors:

- Temperature Sensor: Monitors the temperature of the cells to prevent overheating.
- Fire Sensor: Detects smoke temperature rise or gas emissions from the battery pack.
- Current Sensor: Monitors the current flowing into and out of the battery pack.
- Voltage Sensor: Measures the voltage of individual cells or groups of cells.

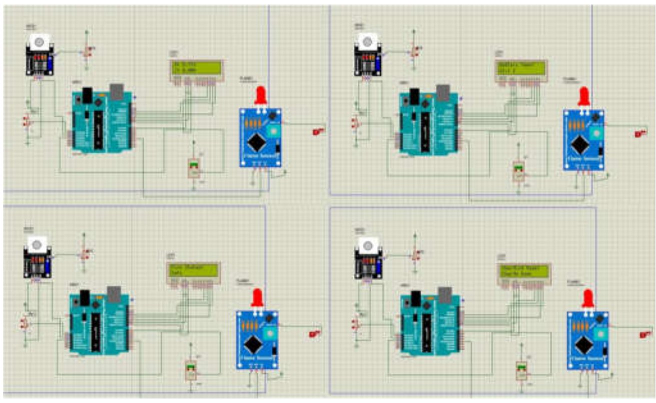
Arduino UNO:

Arduino Uno is a widely used open-source microcontroller board based on the ATmega328P chip. It operates at 5V with a 16 MHz clock speed and has 14 digital I/O pins (6 PWM) and 6 analog inputs. The board includes 32 KB of flash memory for programs and supports communication protocols like UART, SPI, and I2C.

Protection Circuit:

The protection circuit regulates power flow for safe and efficient charging. It uses an AC-DC converter, onboard charger, and charge controller to manage voltage and current, protecting the battery from overcharge and overheating. The process follows constant current and constant voltage modes, with communication protocols like CAN for monitoring and control.

3.2 Circuit Diagram



A Battery Management System (BMS) with a charge monitor typically works by monitoring the charge level of the battery pack and controlling the charging process to ensure the battery is charged safely and efficiently.

Basic Steps Involved:

- ✓ **Charge monitoring:** The BMS monitors the charging current and voltage of the battery pack to determine its state of charge (SOC).
- ✓ **Charge control:** Based on the SOC information, the BMS controls the charging process by adjusting the charging current and voltage to prevent overcharging and overheating.
- ✓ **Charge balancing**: The BMS also ensures that the individual cells in the battery pack are balanced, meaning they are charged to the same voltage level, to prevent overcharging of any cell.
- ✓ **Data collection:** The BMS collects and stores data about the battery's performance and health, such as its charge level, charging and discharging history, temperature, and any abnormalities detected during operation.
- ✓ **Communication:** The BMS communicates with the user or the system in which the battery is installed, providing real-time data about the battery's performance and health.

4. SYSTEM DESIGN

4.1 Hardware Design

The Battery Management System (BMS) for Electric Vehicles (EVs) with integrated charge monitoring and fire protection is essential for ensuring the safety, efficiency, and longevity of EV batteries.

4.2 Modular Design

Scalability:

- ✓ The BMS is designed to accommodate various battery configurations, allowing for easy scalability as battery technology evolves.
- ✓ Replaceable Components: Key components, such as sensors and communication modules, can be easily replaced or upgraded without redesigning the entire system, facilitating maintenance and future enhancements.

2. Charge Monitoring

- ✓ Real-Time Data: The system continuously monitors the state of charge (SoC), voltage, and current of each cell, providing real-time data to optimize battery performance.
- ✓ Balancing Mechanism: It includes cell balancing capabilities to ensure uniform charging and discharging, extending battery life and enhancing efficiency.

3. Fire Protection

- ✓ Temperature Sensors: Integrated temperature sensors monitor battery cell temperatures to detect overheating, triggering protective measures if thresholds are exceeded.
- ✓ Fire Suppression System: The BMS can incorporate a fire suppression mechanism, such as a thermal runaway protection circuit, that activates cooling measures or isolates affected cells to prevent fire hazards.

4. Energy-Efficient Design

- ✓ Low Power Consumption: The BMS components are designed for minimal energy consumption, optimizing battery life and efficiency during operation.
- ✓ Smart Algorithms: Advanced algorithms manage power distribution and thermal conditions, enhancing overall system efficiency while safeguarding battery health.

5. Enclosure Design

- ✓ Robust Housing: A durable enclosure protects sensitive components from environmental factors and physical damage, ensuring reliable operation under various conditions.
- ✓ Ventilation Features: The design includes ventilation ports to promote airflow and dissipate heat, reducing the risk of overheating during operation.

6. Communication and Integration

- ✓ Data Transmission: The BMS supports communication protocols (e.g., CAN, UART) for seamless integration with the vehicle's onboard systems, allowing for efficient data sharing and control.
- ✓ User Interface: An intuitive user interface provides operators with essential information about battery status, charge levels, and system alerts, enhancing user experience and safety.
- ✓ This comprehensive design ensures that the EV BMS not only efficiently manages battery performance but also prioritizes safety through effective charge monitoring and fire protection mechanisms.

4.3 Software Design

1. Charge Monitoring

- ✓ Real-Time Monitoring: Continuously tracks the state of charge (SoC), voltage, and current of individual battery cells to optimize performance.
- ✓ Data Acquisition: Uses high-precision Analog-to-Digital Converters (ADCs) to ensure accurate measurement of battery parameters, providing essential data for decision-making.

2. Communication Layer

- ✓ Protocol Support: Integrates communication protocols such as CAN or UART for seamless data transmission between the BMS and the vehicle's central control unit.
- ✓ Data Logging: Records historical data on battery performance, enabling analysis and reporting for maintenance and operational efficiency.

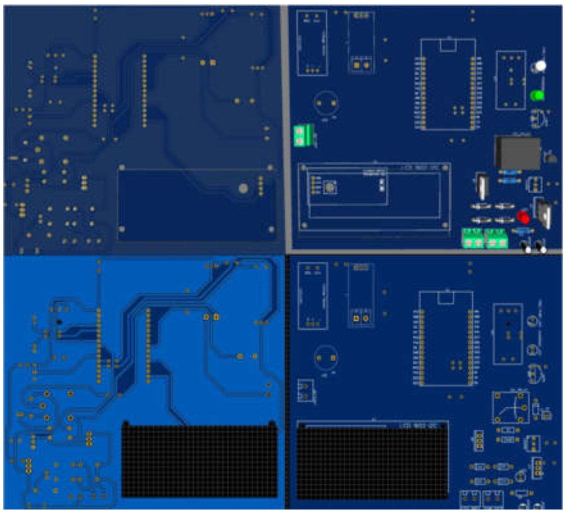
3. Data Processing Layer:

- ✓ Filtering Algorithms: Implements algorithms to filter out noise from sensor readings, ensuring reliable data is used for monitoring and control.
- ✓ Balancing Logic: Includes cell balancing algorithms that distribute charge evenly across cells to prevent overcharging and enhance battery lifespan.

4. Fire Protection Mechanism:

- ✓ Thermal Sensors: Incorporates temperature sensors to monitor battery cell temperatures, alerting the system to potential overheating risks.
- ✓ Emergency Shutdown: Features an automatic shutdown mechanism that disconnects battery packs if temperatures exceed safe thresholds, preventing fire hazards.

4.4 PCB DESIGN



Components Mounted on the PCB:

a. **Arduino Uno Headers:** Female headers for plugging in Arduino Uno securely.
b. **Voltage Sensor Interface:** Terminal blocks and traces for connecting voltage dividers from battery cells to analog pins of Arduino.
c. **Temperature Sensors:** Pads or connectors for LM35/DHT11 sensors placed near cells for accurate thermal feedback.
d. **Relay Module Pins:** Interface to control high-current switching for battery cut off during faults.
e. **Buzzer Output:** Connected to a digital pin for audible alert signals.
f. **16x2 LCD Pins:** Layout provided for I2C or parallel LCD connection with pull-up resistors.
g. **Power Supply Section:** Voltage regulator circuit (if needed) to supply 5V from battery to sensors and Arduino safely.

4.5 Algorithm

The algorithm for the Battery Management System (BMS) of Electric Vehicles (EVs) with charge monitoring and fire protection is designed for continuous operation and safety, operating as follows:

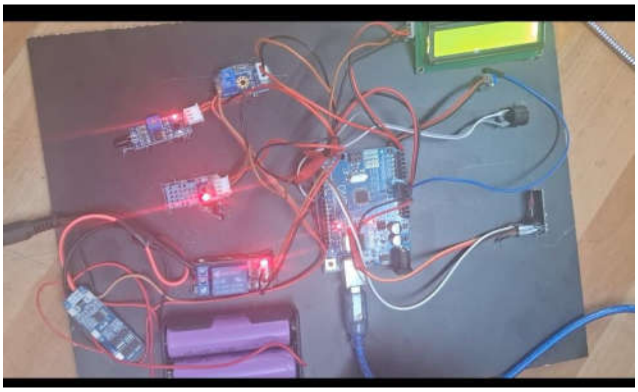
1. **Read Sensor Data:**
   Continuously gather data from battery cells, including voltage, current, and temperature and store the collected data in the BMS’s memory for real-time processing.
2. **Filter Data:**
   Apply filtering techniques to minimize noise and fluctuations in the sensor readings. Ensure reliable measurements for better decision-making regarding battery management.

3. **Transmit Data:**
   Communication with Vehicle Systems: Use communication protocols (e.g., CAN or UART) to transmit data to the vehicle's central control unit for integrated monitoring and control.
   Alert Notifications: If anomalies are detected (e.g., overvoltage, overheating), send alerts to the user interface or external monitoring systems.

4. **LogDataLocally:**
   Store historical performance data in the BMS’s memory, allowing for review and analysis of battery health over time .Enable periodic reports for maintenance and diagnostic purposes.

5. **CheckforAlerts:**
   Trigger visual or auditory alerts if abnormal conditions are detected, ensuring the driver is informed of potential issues. Provide updates on battery status, charge levels, and any alerts on the vehicle's dashboard display.

5 RESULT



Objective Recap:

The primary goal of this project was to design and implement a cost-effective Battery Management System (BMS) for Electric Vehicles that:

- Monitors battery voltage and charge levels
- Detects overvoltage, under voltage, and temperature anomalies
- Provides real-time display of data
- Triggers fire protection mechanisms when needed

System Functionality Testing:

Test Parameter	Expected Outcome	Observed Result
Voltage Monitoring	Detect cell voltage range (3.0V – 4.2V)	Accurate readings via voltage divider and ADC
Temperature Monitoring	Detect temperature rise above 60°C	LM35 detected real-time temperature reliably
Charge Display	Show voltage and temperature on LCD	16x2 LCD displayed live data successfully
Overvoltage Condition	Trigger buzzer + relay cutoff	Buzzer activated and relay disconnected power
Overheating Condition	Alert through buzzer and shutoff	Buzzer beeped and shutdown triggered at >60°C
Undervoltage Condition	Show warning for battery discharge	Warning triggered correctly

6 CONCLUSION

The proposed system is useful in monitoring and tracking the properties of the battery in real time. The battery plays a vital role in an Electric vehicle. Therefore monitoring of the Battery is very important. The project proposed a new way monitoring the battery with the help IOT. The sensors incorporated in the proposed system can collect the data of battery such as voltage, temperature and current, these data is then sent to Arduino IOT Cloud. Thus the real time data collection, storage and monitoring of the battery of an electric vehicle is possible with the system. By tracking these variables, it will be easier to determine the battery's health or longevity, and pricing will be adjusted accordingly, as a less efficient battery with a shorter life cycle will cost more than a more efficient battery with a longer life cycle. This helps in identifying and solving a problem before a failure without human dependency. In addition measured data helps to develop a battery swapping station and its price fixing.

REFERENCES

1. J. Li, J. Fan, and J. Li, "A novel active cell balancing scheme for series-connected battery packs of electric vehicles," IEEE Transactions on Vehicular Technology, vol. 68, no. 5, pp. 4138-4148, May 2019.

2. Shah, F.A., Sheikh, S.S., Mir, U.I. and Athar, S.O., 2019, August. Battery health monitoring for commercialized electric vehicle batteries: Lithium-ion. In 2019 International Conference on Power Generation Systems and Renewable Energy Technologies (PGSRET) (pp. 1-6). IEEE.

3. W. Cheng, X. Luo, and B. Yang, "Online fault diagnosis for lithium-ion batteries in electric vehicles using neural network ensemble," IEEE Transactions on Industrial Informatics, vol. 14, no. 4, pp. 1735-1744, Apr. 2018.

4. Y. Liu, X. Qian, and H. Guan, "Development of electric vehicle battery management system with charge balance control," IEEE Transactions on Power Electronics, vol. 28, no. 6, pp. 2901-2908, Jun. 2013.

5. Rajashekara, K., 2013. Present status and future trends in electric vehicle propulsion technologies. IEEE journal of emerging and selected topics in power electronics, 1(1), pp.3-10.

6. Guarnieri, M., 2012, September. Looking back to electric cars. In 2012 Third IEEE History of Electro-technology Conference (HISTELCON) (pp. 1-6). IEEE.