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Smart EV Battery Management System with IoT-Based Monitoring, Fire and Theft Protection

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Abstract: *This project presents the design and implementation of a Smart Electric Vehicle (EV) Battery Management System (BMS) integrated with IoT-based monitoring, fire, and theft protection. The system aims to enhance the safety, efficiency, and real-time supervision of EV battery operations. Key features include accurate State of Charge (SOC) estimation, voltage and current monitoring, and live data visualization through the Blynk IoT platform. The system also incorporates overcharge protection by automatically disconnecting the charger once the battery reaches full capacity. Fire safety is addressed using temperature sensor that trigger alerts and activate protective mechanisms when hazardous conditions are detected. Additionally, the project includes an anti-theft module that uses motion sensors to detect unauthorized movement and notify the user instantly. This comprehensive BMS solution ensures improved battery performance, extended battery life, and enhanced vehicle security, making it a reliable advancement in the field of electric mobility*

Keywords: Electric Vehicle (EV), Battery Management System (BMS), Internet of Things (IoT), State of Charge (SOC), Overcharge Protection, Fire Safety, Anti-Theft System, Real-Time Monitoring, Blynk Platform, Voltage and Current Sensing, Temperature Sensor, Motion Detection, Battery Safety, EV Security, Smart Charging.

I. INTRODUCTION

Battery Health Monitoring system (BHMS) is an essential component in electric vehicles (EVs) that regulates and maintains battery performance by monitoring and controlling various factors such as voltage, current, temperature, and state of charge. It helps ensure safe and reliable battery operation, prevent battery damage from overcharging or over-discharging, and maximize the range of the vehicle by optimally using the amount of energy stored in the battery. BHMSs are crucial in electric and hybrid electric vehicles, where they communicate with the on-board charger to monitor and control the charging of the battery pack.

The transition from fossil-fuel vehicles to electric vehicles (EVs) is crucial for reducing carbon emissions and promoting sustainable transportation. At the core of every EV is its battery system, which determines its range, efficiency, safety, and reliability. Proper management of the EV battery is essential for ensuring optimal performance and long battery life.

A Battery Management System (BMS) is responsible for monitoring and controlling battery operations such as voltage, current, temperature, and state of charge (SOC). Traditional BMS units, however, offer only basic functionalities and lack advanced features such as real-time data monitoring, smart safety measures, and remote access.

To overcome these limitations, this project proposes a Smart EV Battery Management System integrated with IoT-based monitoring, fire detection, and theft protection. This system enables real-time data transmission to the user's mobile phone, automatic fire alerts, overcharge protection, and GPS-based theft detection, providing a complete and intelligent solution for modern EVs.

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II. LITERATURE REVIEW

1) B. Homan, Comprehensive Model for Battery State of Charge Prediction - 2018

In this existing system, the relatively simple model for State of Charge prediction, based on energy conservation for Pb-acid, Li-ion and Sea salt batteries verified. The model is further improved to accommodate the rate capacity effect and the capacity recovery effect, the improvements are verified with lead-acid batteries. For further verification the model is applied on a realistic situation and compared to measurements on the behavior of a real battery in that situation. Furthermore, the results are compared to results of the well-established KiBaM model. Predictions on the SoC over time done using the proposed model closely follow the SoC over time calculated from measured data. The resulting improved model is both simple and effective, making it especially useful as part of smart control, and energy usage simulations.

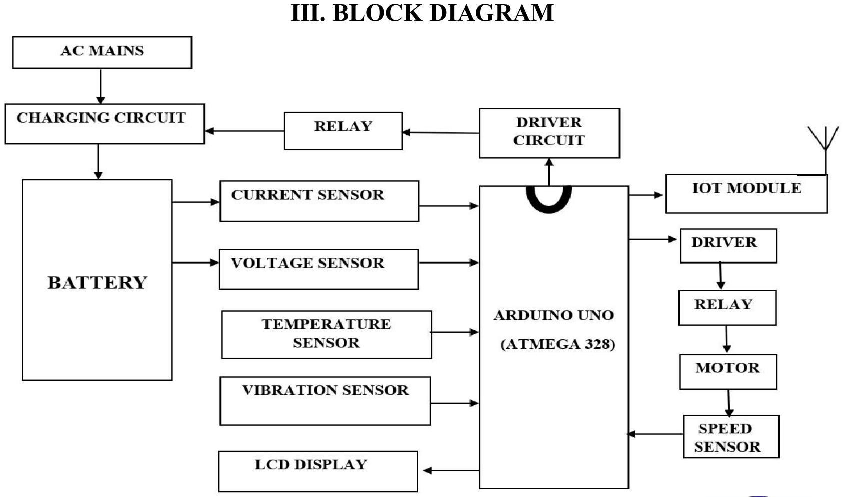
2) M. R. Sarker, proposed, "Optimal operation of a battery energy storage system: Trade-off between grid economics and storage health," Electric Power Systems Research, 2017

They have battery participants in performance-based frequency regulation markets must consider the cost of battery aging in their operating strategies to maximize market profits. In this paper we solve this problem by proposing an optimal control policy and an optimal bidding policy based on realistic market settings and an accurate battery aging model. The proposed control policy has a threshold structure and achieves near-optimal performance with respect to an offline controller that has complete future information. The proposed bidding policy considers the optimal control policy to maximize market profits while satisfying the market performance requirement through a chance-constraint. It factors the value of performance and supports a trade-off between higher profits and a lower risk of violating performance requirements. They demonstrated the optimality of both policies using simulations.

3) J. Jeong, proposed, "A 42nJ/conversion on-demand state-of-charge indicator for miniature IoT Li-ion batteries – 2016.

In this existing system an energy efficient State-of-Charge (SOC) indication algorithm and integrated system for small IoT batteries are introduced in this paper. The system is implemented in a 180-nm CMOS technology. Based on a key finding that small Li-ion batteries exhibit a linear dependence between battery voltage and load current, we propose an instantaneous linear extrapolation (ILE) algorithm and circuit allowing on-demand estimation of SOC. Power consumption is 42nW and maximum SOC indication error is 1.7%. To verify the accuracy, the measured EMF with ILE is compared with VOC by slow voltage relaxation. Prior to system design, we experimentally confirmed that EMF yields an accurate estimation of SOC in small IoT batteries with little dependency on discharge cycle count and temperature by characterizing 12µAh Li-ion batteries.

III. BLOCK DIAGRAM



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IV. HARDWARE COMPONENTS

1. **Arduino UNO**

• **Type**: Microcontroller board based on ATmega328P

• **Role**: Acts as the brain of the system. It reads inputs from switches and the ultrasonic sensor, processes them, and controls

FEATURE

Microcontroller: ATmega328P
Operating voltage: 5V
Input voltage: 7-12V
Flash memory: 32KB
SRAM: 2KB
EEPROM: 1KB

Fig 1 Arduino.

2. IoT Module (ESP8266)

• **Type**: Communication Module

• **Role**: Sends real-time data to Blynk IoT platform

Fig 2 IoT Module (ESP8266)

FEATURES:

Wi-Fi enabled, remote monitoring, compact size

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3. 16x2 LCD Display
• **Type**: Character LCD screen
• **Role**: Shows SOC, voltage, current, and temperature
• **Connected via**: Digital pins on Arduino (usually through I2C module or directly)
FEATURES: Real-time display, user-friendly interface

Fig 3 LCD Display.

4. Battery
• **Type:** li on battery
• **Role:** power source

Fig 4 Battery

Features: Rechargeable, monitored for voltage and current

5. Relay Board
• **Type:** Electromechanical switch
• **Role:** Disconnects charger to prevent overcharging

Fig 5 Relay

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FEATURES
Electrically controlled, high current switching

6. Current Sensor
Type: Sensor
Role: Measures charging/discharging current
Features: Real-time current sensing, non-intrusive measurement

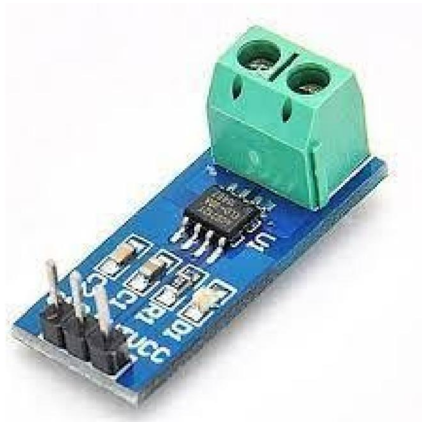


Fig 6 Current Sensor

7. Voltage Sensor
Type: Sensor
Role: Monitors battery voltage for SOC calculation
Features: Simple interface, accurate voltage detection

Fig 7 voltage Sensor

8. Temperature Sensor (e.g., LM35)
Type: Sensor
Role: Detects overheating or fire risk
Features: Analog/digital output, reliable temperature sensing

Fig 8 Temperature Sensor

9. Driver Circuit
Type: Power Interface
Role: Drives high-power devices like relays or motors
Features: Signal amplification, protects microcontroller

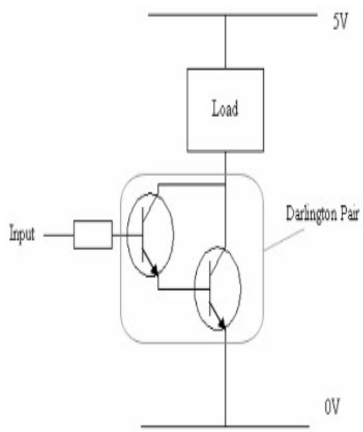
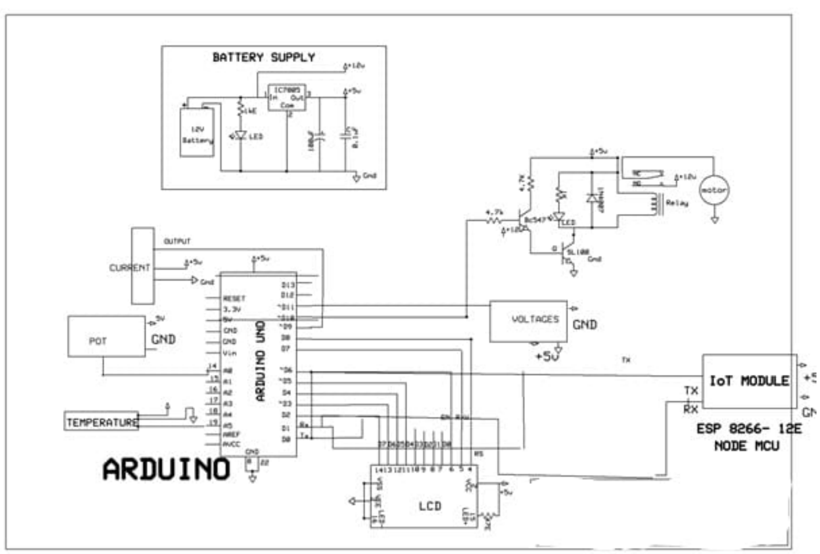


Fig 8 Working of a Darlington Pair Transistor

CIRCUIT DIAGRAM



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CIRCUIT DIAGRAM EXPLANATION

The **Smart EV Battery Management System** integrates multiple components to monitor and protect the electric vehicle's battery. A **microcontroller** collects data from sensors (voltage, current, and temperature) to calculate the **State of Charge (SOC)** and assess battery health. The **IoT module** transmits this data to a cloud platform for remote monitoring. The **relay** disconnects the charger once the battery is fully charged to prevent overcharging. A **temperature sensor** detects overheating, while a **motion sensor** triggers an alarm for theft detection. The **LCD display** shows real-time battery parameters for local monitoring.

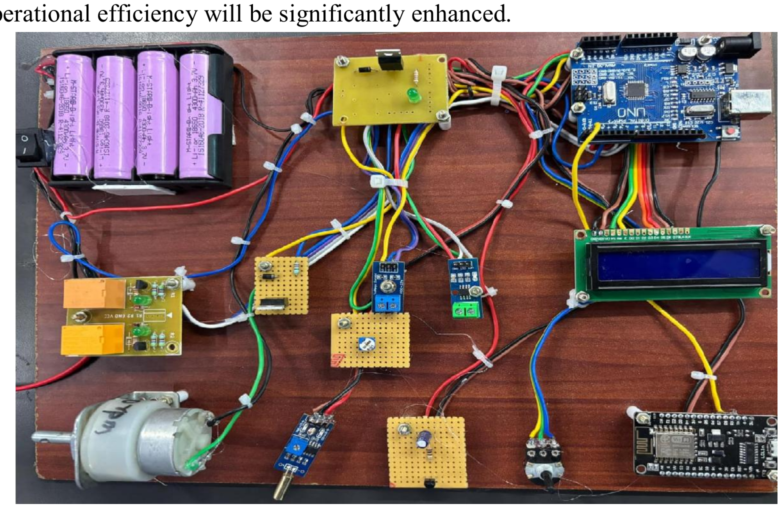
V. PROPOSED SYSTEM

The proposed system aims to design and implement an advanced Smart EV Battery Management System (BMS) that integrates IoT-based monitoring, fire protection, and theft detection. The system will enhance the overall safety, efficiency, and longevity of the battery, which is the core component of electric vehicles.

The system is designed to monitor key battery parameters, such as voltage, current, and temperature, in real time. A microcontroller (e.g., Arduino) will process these data points and perform calculations for accurate State of Charge (SOC) estimation. The data will be displayed on an LCD screen for local monitoring, while an IoT module (e.g., ESP8266/ESP32) will transmit the data to a cloud platform like Blynk for remote monitoring.

To prevent overcharging and ensure battery longevity, the system will use a relay to disconnect the charger once the battery reaches full capacity. Temperature sensors will monitor battery temperature and activate protective measures in case of overheating, reducing the risk of fire. Additionally, a motion sensor will detect unauthorized movement of the vehicle, triggering an anti-theft alert and notifying the owner instantly.

This proposed system will be scalable and adaptable to future advancements in electric vehicle technology, making it a robust solution for both individual EV owners and fleet management systems. By implementing this system, electric vehicle safety and operational efficiency will be significantly enhanced.



SOFTWARE MODULE REQUIRED

1.Arduino IDE

- Used for writing and uploading the code to the Arduino UNO.
- Programming language: C++

2.Proteus Design Suite

- Used for simulating the entire circuit before hardware implementation**.**
- You can test sensors, LCD, and Arduino connections virtually.

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VI. APPLICATIONS

- Used in electric vehicles to monitor and manage battery health and safety.
- Prevents overcharging, overheating, and fire risks using real-time sensors and automatic control.
- Integrated with smart charging stations for intelligent battery supervision.
- Enables remote monitoring of battery parameters through the Blynk IoT platform.
- Provides theft protection by detecting unauthorized movement and sending instant alerts.
- Supports electric vehicle fleet management with real-time tracking of SOC and performance.
- Suitable for academic and industrial research in EV battery management systems.
- Applied in industrial electric transport systems like forklifts and carts.
- Enhances energy efficiency by analyzing charge and discharge cycles accurately.

VII. ADVANTAGES

- Enhances battery safety by preventing overcharging and overheating.
- Enables real-time monitoring of battery parameters using IoT.
- Improves battery life through efficient charging management.
- Provides instant alerts for fire and theft, ensuring better security.
- Reduces maintenance costs by detecting issues early.
- Increases user convenience with remote access and live data visualization.
- Ensures optimal performance of electric vehicles by accurate SOC estimation.
- Simple, cost-effective implementation using Arduino and readily available components.
- Supports future upgrades and scalability for advanced BMS features.

VIII. CONCLUSION

The Smart EV Battery Management System with IoT-based monitoring, fire, and theft protection offers a comprehensive solution to the safety, reliability, and efficiency challenges of electric vehicle battery systems. By integrating sensors for voltage, current, and temperature monitoring, the system effectively tracks battery health and accurately estimates the State of Charge (SOC). The use of a relay-based overcharge protection mechanism safeguards the battery from damage due to excess charging. Additionally, real-time data visualization through the Blynk IoT platform ensures remote supervision and user convenience. The incorporation of fire and theft detection modules further enhances the security of the vehicle. Overall, the project demonstrates a practical, cost-effective, and scalable approach to managing EV batteries, contributing to the advancement of smart electric mobility.

REFERENCES

[1]ChenDuan;CaishengWang;ZongzhengLi;JianfeiChen;ShidaoWang;Adri anSnyder;Chenguang Jiang "A Solar Power-Assisted Battery Balancing System for Electric Vehicles" IEEE Transactions on Transportation Electrification, Volume: 4,Issue: 2, 2018

[2] Juliette Ugirumurera;Zygmunt J. Haas"Optimal Capacity Sizing for Completely Green Charging Systems for Electric Vehicles "IEEE Transactions on Transportation Electrification, Volume: 3, Issue: 3, 2017

[3] S. Negarestani, M. Fotuhi-Firuzabad, M. Rastegar, and A. RajabiGhahnavieh, "Optimal Sizing of Storage System in a Fast Charging Station for Plug-in Hybrid Electric Vehicles," IEEE Trans. Transp. Electrify., vol. 2, no. 4, pp. 443-453, Dec. 2016.

[4] W. Lee, L. Xiang, R. Schober, and V. W. Wong. Electric vehicle charging stations with renewable power generators: A game-theoretical analysis. IEEE Trans. Smart Grid, 6(2):608-617, 2015

[5] Chimaobi N. Onwuchekwa,and Alexis Kwasinski, "A Modified TimeSharing Switching Technique for Multiple-Input DC DC Converters" IEEE TRANSACTIONS, VOLUME. 27, NUMBER. 11, NOV 2012

[6] W. Tushar, C. Yuen, S. Huang, D. B. Smith, and H. V. Poor. Cost minimization of charging stations with photovoltaics: An approach with EV classification. IEEE Trans. Intell. Transp. Syst., 17(1): 156-169, 2016.

[7] E. Veldman and R. A Verzijlbergh. Distribution grid impacts of smart electric vehicle charging from different perspectives. IEEE Trans. Smart Grid, 6(1):333-342, 2015