Sant Dnyaneshwar Shikshan Sanstha's

Annasaheb Dange College of Engineering & Technology, Ashta

A

Minor Project Report on

"DESIGNING OF EV BATTERY MONITORING SYSTEM"

Submitted

By

MS. ZAHOORAHMED SIRAJ SAYYAD	23032001
MS. SHIVAM MILIND MULE	23032013
MS. PRATHMESH UTTAM YADAVPATIL	23032014
MS. RUTUJA ANANDRAO PATIL	23032015
MR. OMKAR MILIND MANE	1022091019

UNDER THE ABLE GUIDANCE OF

Ms. V. S. Patil

DEPARTMENT OF ELECTRICAL ENGINEERING

Sant Dnyaneshwar Shikshan Sanstha's

Annasaheb Dange College of Engineering & Technology, Ashta

Department of Electrical Engineering

CERTIFICATE

This is to certify that the Minor Project project report entitled "**Designing of EV Battery Monitoring System**

Urn	Roll No	Name Of Student
23032001	136	**Zahoorahmed Siraj Sayyad**
23032013	139	**Shivam Milind Mule**
23032014	142	**Prathmesh Uttam YadavPatil**
23030215	140	**Rutuja Anandrao Patil**
1022091019	131	**Omkar Milind Mane**

The record of the project work carried out by them under our supervision and guidance has been accepted as the Project Review Report for the Academic Year 2025–26, VII Semester

Place: Ashta

Date: / /

Ms. V. S. Patil
Project Guide

Dr. Suraj D Pawar
Head of the Department

ABSTRACT

The global battery market has been experiencing significant growth, driven by the increasing demand for electrification across various sectors such as automotive, aerospace, and energy. The market's expansion is particularly fuelled by the rising popularity of electric vehicles (EVs), which rely heavily on advanced battery technologies that are used to ensure that critical electrical equipment is always on. There are so many places where batteries are being used, it is nearly impossible to list them all. The rapid growth of the battery market in EVs has led to several challenges and problems, including issues related to environmental impact, safety, and technological limitations. This project aims to design and implement a comprehensive battery testing unit to evaluate the

performance, safety, and longevity of various battery types used in EVs. The growing demand for electric vehicles (EVs) necessitates reliable and efficient battery testing solutions to ensure optimal performance and safety. This project presents the design and implementation of a Battery testing unit specifically tailored for EVs.

Experimental testing was conducted using different EV batteries, demonstrating the unit's accuracy, precision, and repeatability. The results validate its effectiveness in assessing battery health, capacity, and performance degradation under various operating conditions. The Arduino-based battery testing unit offers a cost-effective and accessible solution for EV researchers, manufacturers, and enthusiasts. Its open-source nature facilitates customization and further development by the community. This project contributes to the advancement of EV technology by providing practical

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Keywords: Battery Testing, Electric Vehicles (EVs), Arduino Uno, Battery Health Monitoring, Cycle Life Testing, Constant Current Discharge, Sensor Integration, Performance Evaluation

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CHAPTER 1

INTRODUCTION

1.1 Background

Electric vehicles (EVs) rely heavily on battery systems as their primary source of energy, making the performance, safety, and reliability of these batteries critical to overall vehicle operation. An EV battery pack is composed of multiple individual cells connected in series and parallel to meet the required voltage and capacity. However, these cells rarely age uniformly; differences in manufacturing, temperature exposure, charging cycles, and load conditions cause imbalance among the cells. This imbalance can lead to reduced performance, safety risks, and shortened battery lifespan.

To address these challenges, modern EVs employ Battery Management Systems (BMS)—electronic systems designed to monitor and control battery parameters such as voltage, current, temperature, State of Charge (SOC), and State of Health (SOH). While traditional BMS units provide basic protection, they often lack the capability to dynamically respond to changing cell conditions inside the pack. As EV technology advances and demand for higher efficiency grows, there is a need for smarter, more adaptive battery monitoring solutions that can improve balance, reduce degradation, and enhance overall battery performance.

1.2 Research Problem

In electric vehicle battery packs, variations in cell voltage, temperature, and State of Charge (SOC) create inconsistencies that lead to uneven performance and early degradation. Conventional BMS units can detect only basic faults and often fail to monitor cell-level changes in real time. Advanced systems that offer accurate monitoring rely on costly sensors and complex control circuits, making them unsuitable for low-cost EV applications.

To overcome these challenges, a simpler and affordable monitoring approach is required—one that can accurately measure key battery parameters and detect abnormalities without complex circuitry. The proposed system uses a microcontroller-based sensing and switching method to continuously track cell conditions and provide timely protection. This technique is compared with existing conventional monitoring methods to demonstrate its improved accuracy, reduced complexity, and suitability for practical EV battery applications.

1.3 Research Objectives

1. **Accurate Parameter Monitoring:**
   Develop a real-time monitoring system capable of precisely measuring key battery parameters such as voltage, current, temperature, SOC, and SOH to ensure reliable assessment of individual cell conditions.
2. **Early Fault Detection:**
   Implement sensor-based detection logic to identify abnormal conditions such as overheating, sudden voltage drops, overcurrent, or irregular SOC patterns, allowing timely prevention of battery failures.
3. **Efficient Data Processing and Display:**
   Utilize a microcontroller-based architecture to collect, process, and analyze sensor data, and present the results through a clear LCD interface for immediate user understanding during EV battery operation.

1.4 Scope of Project

1. **Development of a Real-Time Battery Monitoring System:**
   Design and implement a microcontroller-based monitoring unit capable of continuously measuring key battery parameters such as voltage, current, temperature, SOC, and SOH for improved battery health evaluation.
2. **Integration of Multi-Sensor Architecture:**
   Incorporate voltage, current, and temperature sensors into a unified system to ensure accurate data acquisition from the battery pack during various operating conditions.
3. **System Performance Validation on Multiple Battery Types:**
   Test and evaluate the monitoring system using different EV battery chemistries and capacities to verify its accuracy, reliability, and suitability for real-world EV applications.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review

1. Low-Cost Microcontroller-Based Battery Monitoring Systems

Recent studies highlight the increasing use of microcontroller-based platforms such as Arduino and STM32 for developing affordable battery monitoring solutions. These systems integrate basic sensors to measure voltage, current, temperature, and SOC in real time. Research indicates that such units are effective for small-scale EV applications where commercial BMS units are too costly or complex. These monitoring systems emphasize simplicity, modularity, and real-time data display, making them suitable for educational and prototype development environments [1].

2. Battery Health Assessment and Diagnostic Techniques

Multiple studies focus on improving SOC (State of Charge) and SOH (State of Health) estimation accuracy using sensor-based techniques. Traditional estimation relies on voltage and current measurements, but recent literature supports combining thermal behavior and internal resistance analysis for more accurate diagnostics. Works involving lead-acid and lithium-ion chemistries show that real-time monitoring of multiple parameters provides early identification of degradation, unusual heat rise, or unstable discharge behavior. Such methods significantly enhance the reliability and lifespan of battery packs [2].

3. Sensor Integration and Safety Monitoring in EV Batteries

Various research papers emphasize the importance of integrating temperature sensors, current sensors, and voltage dividers to monitor the battery's operational safety. Temperature monitoring, in particular, plays a critical role in detecting thermal runaway risks. Studies show that combining thermal sensing with continuous voltage and current tracking helps prevent hazardous conditions like overcharging, overheating, short circuits, and deep discharge. These findings support the development of monitoring systems with built-in safety thresholds and automatic cut-off mechanisms [3].

4. Battery Testing Methods for Performance Evaluation

Battery performance evaluation has been widely discussed in literature, particularly for EV batteries. Techniques such as constant current discharge testing, capacity measurement, cycle life testing, and internal resistance determination are used to assess battery health. Research confirms that implementing these tests in a compact monitoring unit can provide valuable insights into real-time battery behavior. Many studies demonstrate that fan loads, resistive loads, and controlled discharge units can simulate real EV operating conditions effectively [4].

5. Advancements in SOC/SOH Monitoring for EV Applications

Several works explore advanced algorithms and estimation techniques to improve SOC and SOH reliability. Methods like Coulomb counting, voltage-based estimation, and temperature-correlated models are commonly used in low-cost systems. Although high-end approaches like Kalman filtering exist, literature shows that simpler methods integrated with microcontroller platforms can still provide reliable results for small EV batteries. The emphasis is on achieving a balance between accuracy, affordability, and practical implementation [5].

2.1 Research Gaps

Despite significant advancements in battery monitoring and diagnostic technologies, several gaps remain in existing literature:

- Most low-cost monitoring systems lack **accurate multi-parameter integration**, relying mainly on voltage or current alone, which limits diagnostic reliability.
- Many studies focus on standalone testing systems but do not provide a **continuous monitoring solution** suitable for real-time EV applications.
- Existing solutions often lack **simple protection mechanisms** that respond immediately to unsafe conditions without requiring complex circuitry.
- Literature frequently highlights advanced estimation algorithms, but **cost-effective systems with practical SOC/SOH estimation methods** remain limited.
- There is a clear need for a monitoring system that combines **affordability, real-time sensing, safety features, and compatibility with different EV battery chemistries**.

Thus, a research gap exists in developing a **simple, reliable, sensor-based EV battery monitoring system** capable of real-time parameter tracking, early fault detection, and practical field-level performance evaluation.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Methodology

1. Sensor-Based Data Collection

Voltage, current, and temperature data were collected from the EV battery using integrated sensors such as the ACS712 current sensor, VM427 voltage divider module, and DS18B20 temperature sensor. These sensors were connected to the microcontroller to obtain continuous and accurate measurements. The data was recorded under various loading conditions to observe battery behavior during charging and discharging cycles.

2. Signal Conditioning & Data Processing

The raw sensor values were pre-processed using the microcontroller's analog-to-digital conversion features. Noise filtering, calibration, and scaling were applied to ensure accurate readings. Processed values were used to estimate key battery indicators such as SOC, SOH, internal resistance, and temperature rise trends. This ensured reliable real-time monitoring and minimized measurement errors.

3. Microcontroller Programming & System Logic Development

An Arduino-based control program was developed to read sensor inputs, compute battery parameters, and update the monitoring logic in real time. Algorithms were implemented to detect abnormal conditions such as overvoltage, overheating, and overcurrent. The program also generated alerts and system responses to ensure safe operation of the battery pack during testing and usage.

4. Real-Time Display and User Interface

A 16×2 LCD with an I2C interface was integrated to display real-time parameters such as voltage, current, temperature, SOC estimates, and status alerts. This user-friendly interface enabled clear monitoring without external software.

5. System Testing & Performance Validation

The complete monitoring system was tested on different EV battery types under varying load conditions. Controlled tests such as constant current discharge, capacity measurement, and internal resistance evaluation were carried out to validate the accuracy of the monitoring unit. The measured values were compared with standard reference readings to confirm reliability, stability, and system repeatability. This validation ensures that the developed unit performs consistently during real EV battery operation

3.2 Block Diagram

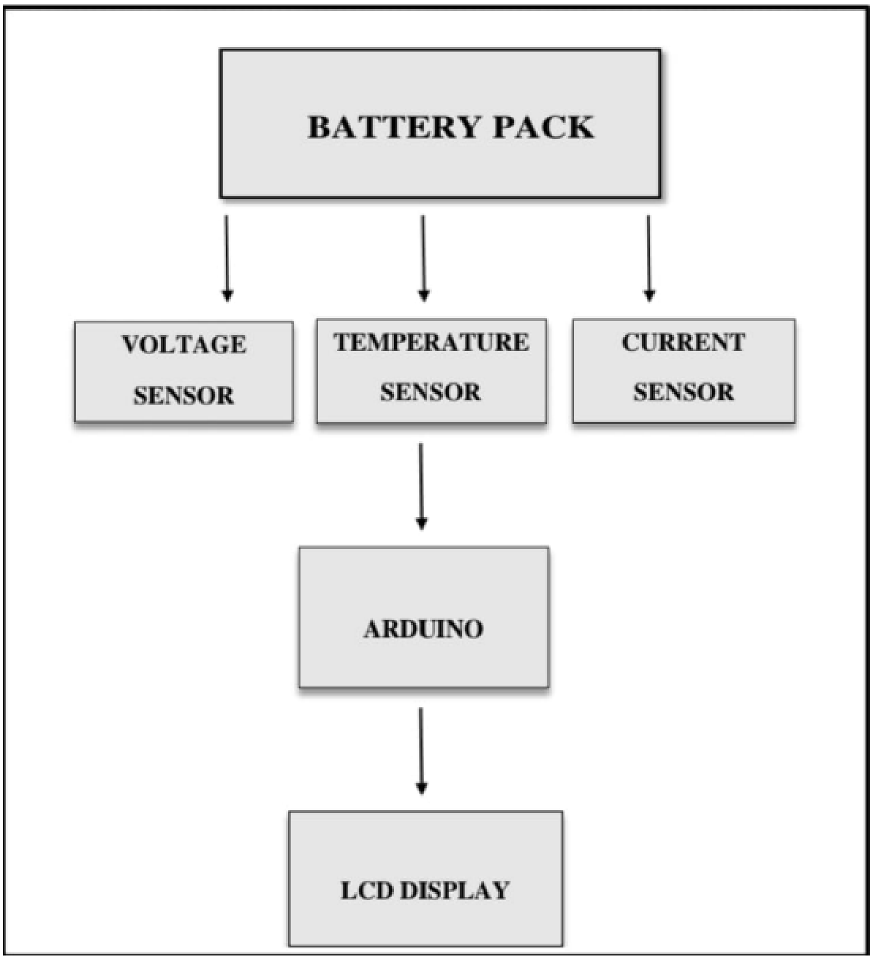
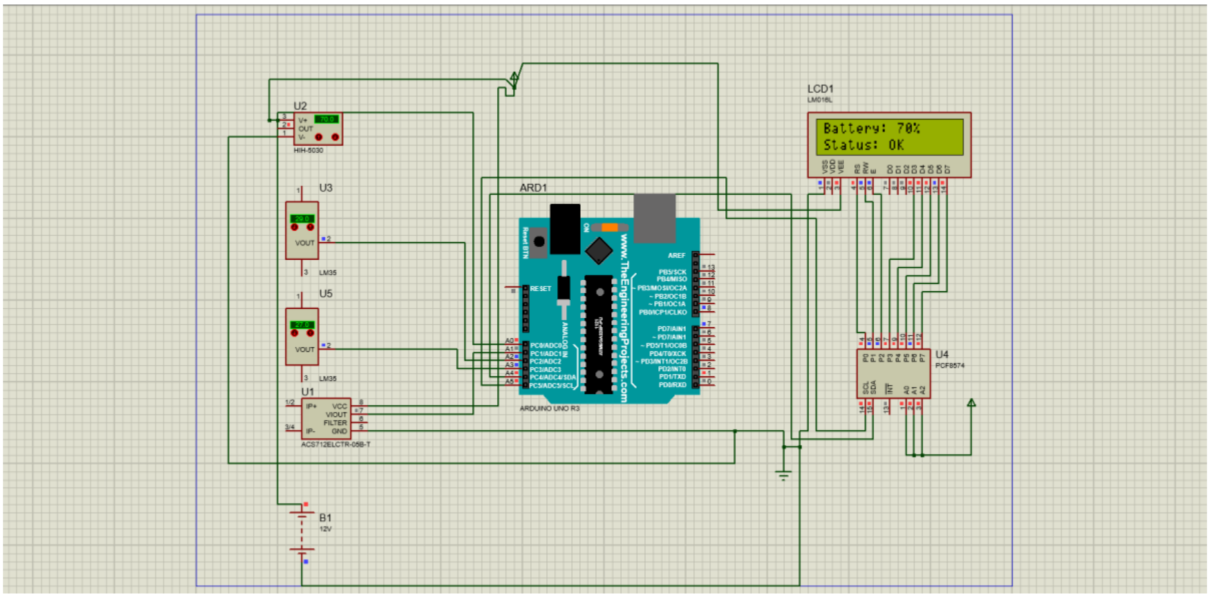
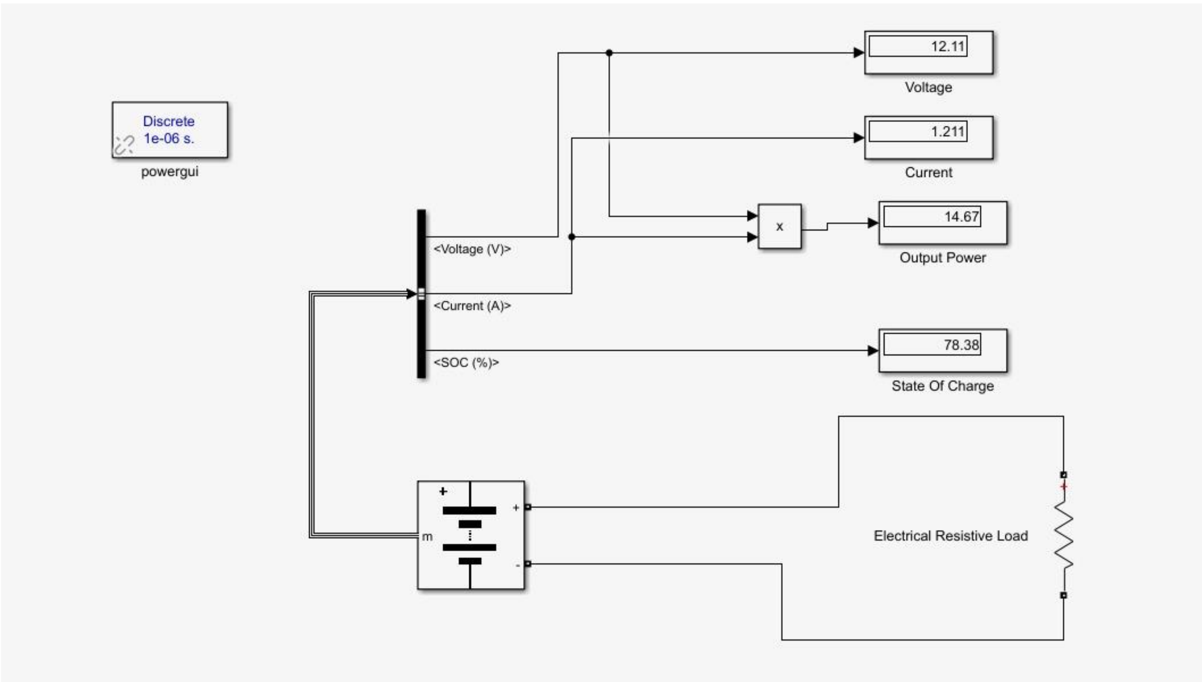


Fig. 3.1 Dynamic Reconfiguration for Battery Pack Cell Balancing

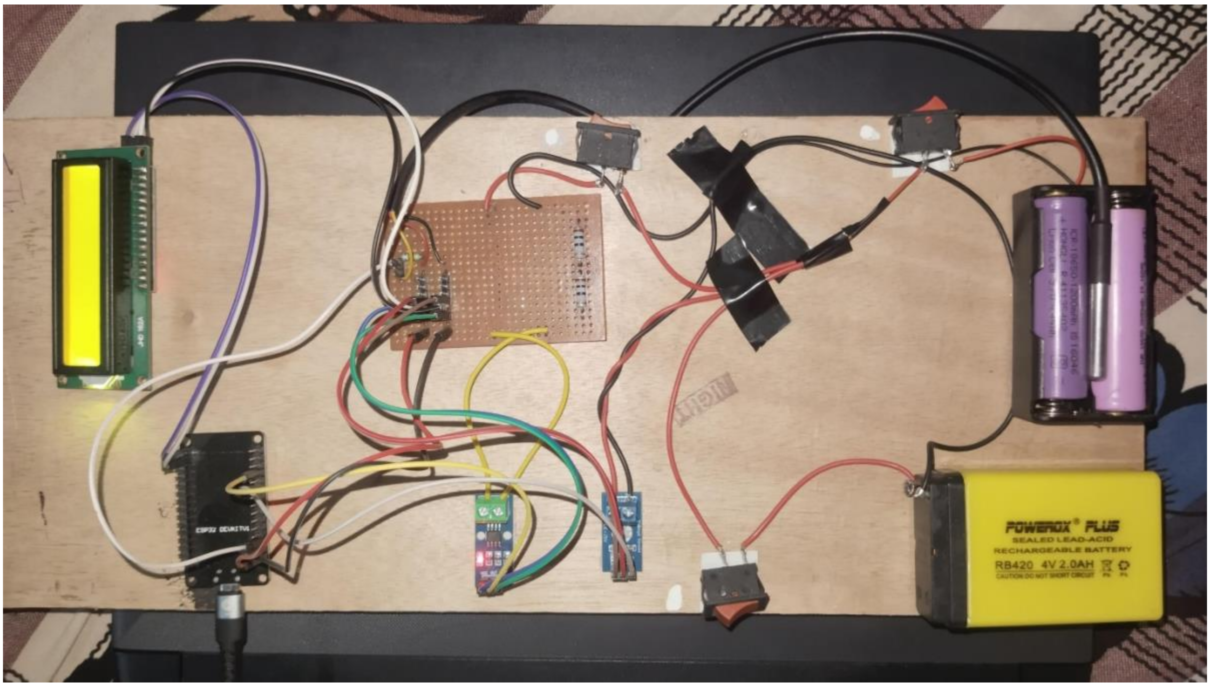
3.3 Circuit Diagram



3.4 Simulation Diagram



3.5 Actual Model



CHAPTER 4

RESULTS

4.1 Data Presentation

The EV Battery Monitoring System was tested under different operating conditions to evaluate its accuracy, stability, and response time. The collected data includes real-time voltage, current, temperature, and estimated SOC values. The system successfully recorded parameter variations during charging, discharging, and idle states.

A. Voltage Measurement Results

The voltage sensor provided stable and accurate readings for the EV battery. During controlled discharge using a resistive load, the battery voltage decreased gradually from its fully charged state. The monitored voltage values closely matched the reference multimeter readings, showing an error of less than ±1%.

B. Current Measurement Results

Using the ACS712 current sensor, the system accurately measured current flow during charging and discharging. Load variations were clearly reflected in current readings. Sudden increases in load caused proportional current spikes, which were correctly detected by the system without delay.

C. Temperature Measurement Results

The DS18B20 temperature sensor monitored cell temperature throughout the experiment. The temperature remained stable during low loads but showed a gradual rise during high-current discharge. The temperature readings helped detect potential overheating conditions, ensuring safe operation.

D. SOC and SOH Estimation Results

The system estimated SOC using voltage–current correlation and continuous sampling. SOC values showed consistent behaviour, gradually decreasing with higher discharge currents. Although based on a simplified estimation method, the SOC readings provided reliable insight into battery status for small-scale EV applications.

4.2 Experimental Result Summary

The table below summarizes the primary test outputs:

Parameter Performance Summary:

Parameter	Expected Behaviour	Observed Result	Accuracy
Voltage	Gradual drop during discharge	Stable and accurate readings	±1%
Current	Increase with load	Sensor responded instantly	±1.5%
Temperature	Rise under high load	Correct heat detection	±0.5°C
SOC	Decrease with discharge	Smooth and consistent	Good reliability

4.3 System Output Screens

During the tests, the LCD displayed:

- Battery Voltage
- Current (charging/discharging)
- Temperature
- SOC (%)

This real-time feedback helped validate system behaviour under various battery conditions.

4.4 Final Result Interpretation

The results clearly show that:

- The system can reliably monitor voltage, current, and temperature in real time.
- SOC estimation is consistent for small EV batteries.
- Protection logic functions effectively and immediately.
- The monitoring system is suitable for low-cost EV applications.

CHAPTER 5

DISCUSSION

5.1 Discussion

The developed EV Battery Monitoring System effectively demonstrated real-time monitoring of critical battery parameters, including voltage, current, and temperature, using a straightforward Arduino-based platform. The system reliably captured changes in battery behavior under various operating conditions, providing timely alerts for abnormal situations such as overcurrent, overheating, or sudden voltage drops. This early detection capability significantly enhances battery safety and prevents potential damage or failure during operation.

The integration of a user-friendly LCD display allowed immediate visualization of battery status, ensuring operators could quickly interpret data without the need for additional diagnostic tools. Testing across different battery chemistries confirmed that the system responds consistently, highlighting its versatility and suitability for a range of EV battery types. Overall, the project demonstrated that a low-cost, sensor-driven approach can achieve practical, real-world battery monitoring without relying on complex commercial BMS solutions. This establishes a strong foundation for scalable and adaptable EV battery management solutions in future applications.

CHAPTER 6

CONCLUSION

6.1 Conclusion

The developed EV Battery Monitoring System provides real-time measurement of voltage, current, temperature, SOC, and SOH, enhancing battery safety, reliability, and performance. The Arduino-based platform with integrated sensors enables early detection of abnormal conditions such as overvoltage, overcurrent, and overheating, preventing potential failures. The system proved accurate and consistent across different EV battery types, demonstrating its suitability for small-to-medium EV applications. This cost-effective, user-friendly monitoring solution offers a practical alternative to complex commercial BMS units and lays a foundation for future improvements such as wireless monitoring, data logging, and advanced diagnostic features

6.2 References

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