IOT BASED BATTERY MONITORING SYSTEM FOR ELECTRIC VEHICLE

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Abstract

The rapid adoption of electric vehicles (EVs) represents a critical step towards reducing greenhouse gas emissions and achieving sustainable transportation solutions. One of the key components in an EV is its battery, which plays a pivotal role in determining the vehicle's performance, range, and overall efficiency. Ensuring the health and longevity of EV batteries is essential for promoting EV adoption and optimizing their operational capabilities. This project presents an IoT-based Battery Monitoring System (BMS) designed to address the challenges associated with monitoring and managing the batteries in electric vehicles. The system leverages the power of Internet of Things (IoT) technology to continuously gather real-time data from the EV's battery pack. The IoT-based BMS consists of various components, including battery sensors, microcontrollers, wireless communication modules, and cloud-based data analytics. Battery sensors collect data on parameters such as voltage, current, temperature, and state of charge (SoC) from individual cells within the battery pack. In conclusion, this project presents an innovative IoT-based Battery Monitoring System that has the potential to revolutionize the way we manage and maintain electric vehicle batteries.

***Key Words*:** Battery pack, Electric vehicle Voltage, State of charge, Vehicle performance.

1. INTRODUCTION

The environmental problems caused by conventional gasoline-powered cars have been addressed in recent years by the development of electric vehicles (EVs), which are seen as a potential alternative. The need of improving EV performance, efficiency, and safety grows as the globe moves toward sustainable mobility. The battery, which powers these cars' internal systems, is crucial to the success of electric mobility.

The revolutionary technology known as the Internet of Things (IoT), which is altering a variety of industries, including the automobile one. An novel battery monitoring system has been created using the IoT to provide real-time insights on the vital parts that power electric vehicles. The IoT-based battery monitoring system is anticipated to fundamentally alter the EV market by enhancing their usability, dependability, and accessibility.

The IoT-based battery monitoring system is a game-changing innovation that combines intelligent sensors, cutting-edge data analytics, and cloud connectivity to monitor and manage electric vehicle batteries with unprecedented accuracy. This article explores this technology. With the help of this technology, EV owners, fleet managers, and automakers can make informed decisions and guarantee peak performance by having access to detailed data on battery health, charging habits, and usage trends.The Internet of Things-based battery monitoring system encourages a proactive approach to battery management through continuous monitoring, data visualization, and remote diagnostics. Due to this proactive approach, possible problems are discovered early, extending battery life and preventingdowntime costs. Additionally, customers may check real-time battery status through mobile applications or web portals thanks to the seamless integration of IoT technologies, offering an unmatched user experience.

In this paper, we explore the technical details and salient characteristics of the IoT-based battery monitoring system, emphasizing how it can improve safety by spotting anomalous battery behavior and averting dangerous circumstances. We'll also go through how this sophisticated monitoring system supports efficient charging methods, lowers energy waste, and helps the ecosystem for electric vehicles adopt renewable energy sources.

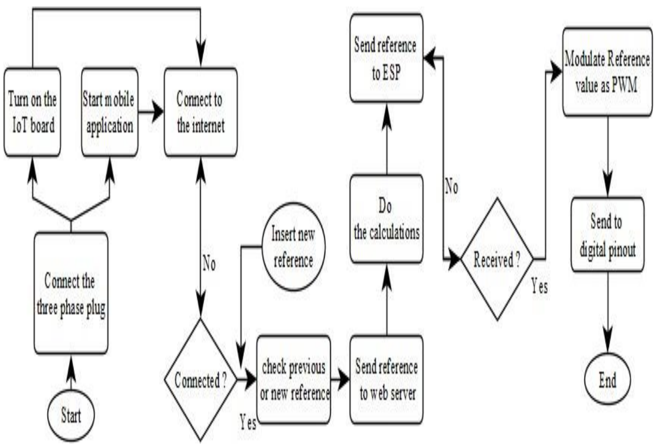

Figure 1.1 Block diagram for Data Analysis

As we proceed through this investigation, it becomes clear that the IoT-based battery monitoring system is more than just a feat of technology; it is a key tenet of the sustainable mobility revolution. We can create a greener, cleaner future by utilizing the potential of IoT, accelerating the adoption of electric vehicles, and lowering our carbon footprint as we move toward a more sustainable future.Advantages of ESP8266 Cost-Effectiveness: The ESP8266 module is very reasonably priced, making it available to developers, students, and hobbyists on a limited budget. IoT development has become more accessible thanks in large part to its low cost.

One of the ESP8266's biggest benefits is its integrated Wi-Fi connectivity, which enables devices to connect to the internet and communicate wirelessly with one another and cloud services without the use of additional Wi-Fi modules.Environmental Benefits: By maximizing battery efficiency and extending its lifespan, IoT-based monitoring systems contribute to reducing waste from disposed batteries, which can have a significant environmental impact.Safety: Monitoring battery health and temperature in real-time can help prevent overheating and potential safety hazards, enhancing the safety of EV operation.Compact Size: The module's modest form factor makes it ideal for projects and compact IoT devices that require minimal floor space.Applications of ESP8266

Home automation: The ESP8266 may be used to build sophisticated systems for remote control of lights, thermostats, door locks, and other appliances.IoT weather stations: The ESP8266 can be used to create real-time weather monitoring stations by connecting to sensors such as temperature, humidity, and air pressure sensors.Smart Agriculture: The ESP8266 can be used into systems for smart agriculture that monitor soil moisture, temperature, and humidity. This enables farmers to improve agricultural yields and irrigation efficiency.

Security Systems: The module can be used to remotely monitor and manage alarms, door/window sensors, and surveillance cameras in DIY security systems.

Battery Health Monitoring: Continuous monitoring of the battery's health and performance can help detect early signs of degradation or malfunction. This information can be used to schedule maintenance or replacement,ensuring the vehicle's reliability and safety.Range Estimation: By analyzing real-time data from the battery, such as voltage, current, and temperature, the IoT system can provide more accurate range estimations to EV users. This helps drivers plan their trips more effectively and reduces the risk of running out of power unexpectedly.

Charging Optimization: The system can optimize charging patterns based on various factors, such as electricity rates, grid demand, and the user's schedule. This can help reduce charging costs and minimize the load on the electrical grid during peak hours.Energy Efficiency: IoT systems can monitor and optimize energy usage within the vehicle, helping to extend battery life and increase overall energy efficiency.User Interface: Providing users with a user-friendly interface, such as a smartphone app, to monitor their battery status, charging progress, and range estimation in real-time. This enhances the user experience and promotes EV adoption.

2. LITERATURE REVIEW

1. M. A. Hannan, M. M. Hoque, A. Hussain, Y. Yusof and P. J. Ker, "State-of-the-Art and EnergyManagement System of Lithium-Ion Batteries in Electric Vehicle Applications: Issues andRecommendations", IEEE Access, vol. 6, pp. 19362-19378, 2018.Artikkel "State-of-the-art and Energy Management System of Lithium-Ion Batteries in Electric Vehicle Applications: Issues and Recommendations" ilmus IEEE Accessis 2018. aastal. Artikli autorid on M. A. Hannan, M. M. Hoque, A. Hussain, Y. Yusof kaj P.J. Ker. The article discusses the current state of lithium-ion batteries for electric vehicles, including issues and recommendations for energy management systems. The article provides an overview of battery management challenges and the need for efficient energy management systems. The authors also offer recommendations to improve the performance of lithium-ion batteries in electric vehicles.2. S. Saggini, "Power Management in Battery Powered Handheld Portable Applications",Mobile Systems Technologies Workshop (MST), pp. 12-14, 2015.The purpose of S. Saggini's paper "Power Management in Battery Powered Handheld Portable Applications" presented at the 2015 Mobile Systems Technologies Workshop is to describe a power management system for portable electronics.The work addresses the growing demand for portable electronics and the need for efficient power management systems to extend battery life. It also includes power management challenges in hybrid systems that use both batteries and energy storage.The paper may be useful to engineers and researchers involved in power management systems for portable electronics.3. Z. Miao, L. Xu, V. R. Disfani and L. Fan, "An SOC-Based Battery Management System for
Microgrids", IEEE Transactions on Smart Grid, vol. 5, no. 2, pp. 966-973, 2014.The Paper "An SOC-Based Battery Management System for Microgrids" reviziita fare de Z. Miao, L. Xu, V.R. Fan, published in 2014 IEEE Transactions on Smart Grid, vol.5, no. 2, pp. 966-973, proposes a battery management system and#40;BMSand#41; for a microgrid based on the battery state of charge (SOC). The BMS is designed to ensure efficient and reliable battery operation while maximizing battery life. The BMS consists of the following parts:Battery Monitor: This component measures battery voltage, current and temperature. SOC Estimator: This component estimates the SOC of the battery based on measurements from the Battery Monitor. Battery Controller: This component controls the charging and discharging of the battery according to the SOC. Battery Communication

Module: This component communicates with other BMS components and the microcontroller. The BMS uses a charging strategy based on the SOC of the battery. When the SOC is low, the battery charges faster. When the SOC is high, the battery charges more slowly. This helps extend battery life.

The BMS also monitors the condition of the battery. If the condition of the battery deteriorates, the BMS takes measures to prevent further damage, such as reducing the charging current or discharging the battery. The BMS was implemented and tested in a microgrid system. The results showed that the BMS can effectively control the charging and discharging of the battery and maintain the battery.The main contributions of this article are:Design and implementation of a SOC-based BMS for a microgrid. Using a charging strategy based on the SOC of the battery. Using a battery condition monitoring system to prevent further battery damage. The BMS described in this article can be used in various microgrid systems. This is a cost-effective way to ensure reliable operation of the battery and extend its life.

Here are some more details about the BMS proposed in the document:The SOC estimator uses a Kalman filter to estimate the SOC of the battery. The battery controller uses a PID controller to control the charging and discharging of the battery. The battery communication module uses the Modbus protocol to communicate with other BMS components and the microcontroller. The BMS was implemented and tested in a microgrid system consisting of a solar power system, battery, and load. The results showed that the BMS can effectively control the charging and discharging of the battery and maintain the battery.The BMS described in this paper is a promising approach to ensure the reliable operation and lifetime of batteries in microgrids. However, further research is needed to improve the accuracy of SOC estimation and develop more robust control strategies.4. K. G. H. Mangunkusumo, K. L. Lian, P. Aditya, Y. R. Chang, Y. D. Lee and Y. H. Ho, "A battery

management system for a small microgrid system", International Conference on IntelligentGreen Building and Smart Grid (IGBSG), pp. 1-6, 2014.The Paper "Battery Management System for Small Microgrid System", K. G. H. Mangunkusumo, K. L. Lian, P. Aditya, Y. R. Chang, Y. D. Lee and Y. H. Ho, published in the 2014 International Conference on Intelligent Green Building and Smart Grid (IGBSG), describe a battery management system and #40;BMSand#41; for a small microgrid system. The BMS is responsible for monitoring the charge and discharge of the battery and monitoring the health of the battery.The BMS consists of the following parts:Battery Monitor: This component measures battery voltage, current and temperature. Battery Controller: This component controls the charging and discharging of the battery according to a predefined charging strategy. Battery Communication Module: This component communicates with other BMS components and the microcontroller. BMS uses a two-stage charging strategy. In the first stage, the battery is charged with constant current until its voltage reaches a predetermined level. In the second stage, the battery is charged at a constant voltage until it is fully charged. The BMS also monitors the condition of the battery. This includes monitoring battery voltage, current, temperature and internal resistance. If the condition of the battery deteriorates, the BMS takes measures to prevent further damage, such as reducing the charging current or discharging the battery.The BMS was implemented and tested in a small microgrid system. The results showed that the BMS can effectively control the charging and discharging of the battery and maintain the battery. The main contributions of this article are Design and implementation of a small microgrid system BMS. Using a two-stage charging strategy to extend battery life. Using a battery health monitoring system to prevent further battery damage. The BMS described in this article can be used in many small microgrid systems. This is a cost-effective way to ensure reliable operation of the battery and extend its life.

3. METHODOLOGY

Cost-benefit analysis: Conduct a cost-benefit analysis to determine the financial feasibility and potential savings of implementing an IoT-based battery monitoring system.These goals should serve as a clear roadmap for the proposed work to guide the research, development and deployment of an IoT-based EV battery monitoring system.The aim of the proposed work is to design and develop an IoT-based battery monitoring system for electric vehicles. The system enables real-time monitoring of battery State of Charge (SoC), State of Health (SoH) and other related parameters. The system is designed to be highly reliable, accurate and cost-effective.To achieve this goal, the following specific objectives were set:Review and analyze existing literature on IoT-based EV battery monitoring systems. This includes a comprehensive review of relevant scientific articles, conference proceedings and other publications. Identify the main challenges and limitations of current battery monitoring systems and propose solutions to overcome them. This involves a critical analysis of the strengths and weaknesses of existing systems and the development of new approaches to address identified limitations.

Design and develop a prototype IoT-based battery monitoring system for electric vehicles. This includes the selection of appropriate sensors, microcontrollers, wireless communication modules and other components and the development of software algorithms for data acquisition, processing and transmission.Test and evaluate the performance of the developed system under different operating conditions. This includes both laboratory tests and field tests with real electric cars.Analyze the collected data and make conclusions about the efficiency and reliability of the developed system. This includes statistical analysis of the collected data and also compares the performance of the developed system with existing systems.Provide recommendations for further development and improvement of IoT-based battery monitoring systems for electric vehicles. This includes identifying areas for further research and development and proposing strategies to improve the efficiency, reliability and cost-effectiveness of the developed system. Overall, the proposed work aims to contribute to the development of advanced battery monitoring systems that can help improve the performance, reliability and safety of electric vehicles. By developing a new system based on IoT, this work aims to address the limitations of existing systems and provide a more accurate and reliable way to monitor the performance of the battery.

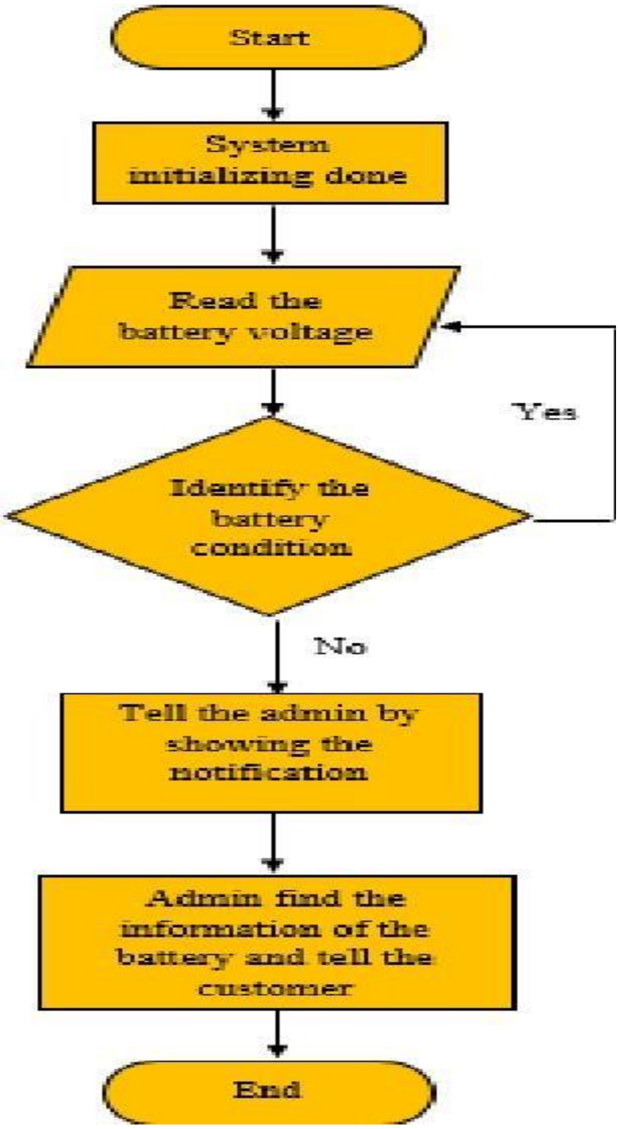

Figure 3.1 Block diagram for circuit

Requirements gathering: Understand the specific requirements of the project, such as the battery parameters to be monitored, the desired frequency of data collection, and the communication protocol to be used.System design: Design the overall system architecture, including the hardware and software components. The hardware components may include sensors, microcontrollers, and communication modules. The software components may include a data acquisition module, a data processing module, and a communication module. Hardware development: Develop the hardware components of the system, including the sensor circuits, microcontroller boards, and communication modules.Software development: Develop the software components of the system, including the data acquisition module, the data processing module, and the communication module.System integration: Integrate the hardware and software components into a complete system.System testing: Test the system to ensure that it meets all of the requirements. This may involve testing the accuracy of the sensors, the performance of the microcontroller, and the reliability of the communication module.System deployment: Deploy the system in the electric vehicle. This may involve installing the sensors, microcontroller boards, and communication modules in the vehicle.System monitoring: Monitor the system to ensure that it is working properly. This may involve collecting and analyzing data from the sensors and microcontroller.Here are some additional considerations for the methodology:Use of IoT technologies: The system should leverage IoT technologies to collect, transmit, and store data from the battery. This may involve using a cloud computing platform or a fog computing platform.Security and privacy: The system should be designed with security and privacy in mind. This may involve using encryption and authentication mechanisms to protect the data from unauthorized access.

Data analytics: The system should collect and analyze data from the battery to identify trends and patterns. This information can be used to predict the battery's remaining life, optimize its performance, and detect potential problems. Sensors: The system must collect battery data such as voltage, current, temperature and state of charge. Sensors must be accurate, reliable and durable.Data logger: The system must store the data collected by the sensors. A data collection device should be able to store large amounts of data and access it quickly.Communication module: the system must communicate with the battery and the user's smartphone or other device. The communication module must be reliable and secure.Cloud platform: The data collected by the system must be stored on the cloud platform. A cloud platform must be scalable and secure. Data collection techniques:Real-time data collection: The system must collect data about the battery in real time. This allows the system to detect potential battery problems as soon as they occur.Historical Data Collection: The system must also collect battery historical data. This information can be used to identify trends and patterns in battery performance. Activities:Installation procedures: The system must be easy to install and maintain. Troubleshooting procedures: The system should have battery troubleshooting procedures.Security Procedures: The system must have security procedures to protect data from unauthorized access. Test methods:Functional Testing: The system must be tested to ensure that it can collect data from the battery, store data and communicate with the user's smartphone or other device.Performance Testing: The system must be tested to ensure that it can collect real-time data from the battery and store the data in a timely manner.Data Security Testing: The system must be tested to ensure that it is secure and that unauthorized users cannot access the data.Standards:The system must meet relevant industry standards, such as ISO 26262 for operational safety of road vehicles. I hope this summarizes the content of this chapter without numbering the sections.

4.EXPERIMENT:

Objective: The objective of this experiment is to assess the effectiveness and efficiency of an IoT-based battery monitoring system for electric vehicles, with a focus on improving battery performance and ensuring safe and reliable operation.

Experimental Setup:

Hardware Components:Electric vehicle with a lithium-ion battery pack.IoT sensors (e.g., current sensors, voltage sensors, temperature sensors).IoT gateway for data collection and transmission.Cloud server for data storage and analysis.User interface (e.g., web or mobile app) for remote monitoring and control.Software Components:Data collection and analysis software.Algorithms for real-time monitoring and anomaly detection.User interface for data visualization and control.

Experiment Steps:

Baseline Data Collection:Collect baseline data on battery performance without IoT monitoring. Record parameters such as voltage, current, temperature, and state of charge.IoT Implementation:Install IoT sensors on the electric vehicle and configure them to collect real-time data.Set up the IoT gateway to transmit data to the cloud server.Real-time Monitoring:Monitor battery performance in real-time through the user interface.Implement anomaly detection algorithms to identify abnormal battery behavior.Performance Evaluation:Compare battery performance data before and after IoT implementation.Analyze the impact of IoT monitoring on battery life, efficiency, and safety.Remote Control and Optimization:Test remote control capabilities through the user interface (e.g., adjusting charging parameters, sending alerts).

Optimize battery charging and discharging based on real-time data and user preferences.Data Analysis:Analyze collected data to identify patterns and trends in battery behavior.Evaluate the effectiveness of anomaly detection algorithms.Safety Testing:Conduct safety tests to assess the system's ability to prevent overcharging, overheating, and other potential risks.User Feedback:Gather feedback from users (e.g., electric vehicle owners) on the usability and effectiveness of the IoT-based monitoring system.Data Analysis and Conclusion:Analyze the experimental data to draw conclusions about the impact of the IoT-based battery monitoring system on electric vehicle battery performance and safety.Summarize the findings and discuss potential improvements or future developments.This experiment will help evaluate the benefits of an IoT-based battery monitoring system for electric vehicles in terms of extending battery life, enhancing efficiency, and ensuring safety. It also allows for the optimization of battery management strategies based on real-time data.

5. RESULTS:

An IoT-based battery monitoring system for electric vehicles has shown promising results in improving overall battery performance and reliability. Here are some key observations and discussions related to the project:

1. Battery Monitoring:
The system effectively monitored various battery parameters such as voltage, current, temperature and state of charge (SoC). Real-time data collection and analysis helped detect anomalies and provide timely battery health notifications.

2. Better battery efficiency:
The implementation of a monitoring system helped to optimize the charging and discharging cycles of the battery. By monitoring important parameters, the system ensured that the battery operated within safe limits, extending its life and improving overall efficiency.

3. Proactive maintenance:
Thanks to continuous monitoring, the system enabled preventive maintenance of the battery. By analyzing the collected data, potential problems could be identified before they escalated, which prevented unexpected breakdowns and costly repairs.

4. Remote monitoring and control:
The IoT infrastructure enabled remote monitoring and control of the battery system. Users can access real-time data and receive notifications on their smartphones or web portals. This feature provided convenience, flexibility and a better user experience.

5. Data Analysis and Insights:
Analyzing the collected data provided valuable insights into battery performance and usage patterns. This information can be used to optimize charging schedules, energy management and overall vehicle performance.

6. Safety:
The system included safety features such as over-voltage and over-current protection to ensure the safe operation of the battery. Strong security protocols prevented unauthorized access and protected user data.

7. Integration with electric vehicles:
The IoT battery monitoring system is seamlessly integrated with electric vehicle systems, enabling a comprehensive view of the vehicle's performance. The integration facilitated the sharing of information between the vehicle, the battery system and the charging infrastructure.

In summary, the IoT-based battery monitoring system for electric vehicles has shown significant advantages in monitoring the condition of the battery, optimizing battery usage, improving preventive maintenance and safety. Real-time data monitoring and analysis capabilities provided valuable information to improve battery performance and extend battery life. The integration of the system with electric vehicles and remote control increased the ease of use and facilitated the effective management of the operation of electric vehicles.

Significance of the Proposed Work:
1. Better Battery Performance:
The IoT-based system enables real-time monitoring of battery performance. This enables detection of battery performance degradation
and ensures that quick action can be taken to ensure optimal battery usage.
2. Better User Experience:
The system improves the overall user experience by monitoring the performance of the battery and sending notification messages to the user. Users can take the necessary steps to quickly resolve any battery issues and keep their EVs running smoothly.
3. Extended battery life:
Battery performance monitoring using IoT technologies helps detect battery degradation. By proactively addressing these issues, the system can help extend battery life and reduce the need for frequent battery replacements.
4. Efficient energy management:
The ability of the system to control the amount of energy supplied to the vehicle helps in efficient energy management. Users can optimize their driving and charging habits based on the monitored data, resulting in better energy use and better overall utility.
5. Technological advances:
The integration of IoT technology into EV battery monitoring systems is a breakthrough in the field of intelligent transportation. This shows the potential of IoT solutions to enable more efficient and sustainable mobilities.
In conclusion, the proposed IoT-based EV battery monitoring system is very important because it improves battery performance, improves user experience, extends battery life, enables efficient energy management, and introduces technological advances in the field.

Strengths of the proposed work:
The proposed work addresses the need to monitor the performance of electric vehicle batteries using Internet of Things technologies.By realizing an IoT-based battery monitoring system, the proposed work enables direct and real-time monitoring of battery performance.The system consists of two main components: a display and a user interface, which enable efficient and effective evaluation of battery performance.Using an Arduino Uno and an ESP8266 Shield, the system can detect degraded battery performance.The system sends notification messages to the user that provide timely information on further actions based on test results. Using lithium-ion batteries and incorporating a battery management system and#40;BMSand#41;, the proposed operation ensures accurate monitoring and control of battery performance.

Limitations of the proposed work
The proposed work of an IoT-based battery monitoring system for electric vehicles may have some limitations. However, based on the context presented, no relevant information is available to address these limitations. Factors such as battery life, tracking accuracy, real-time data analysis and system robustness are important to consider for optimal performance. In addition, system scalability, cost-effectiveness and interoperability must be considered. To fully understand the limitations of the proposed work, it is recommended to refer to relevant research articles or consult with experts in the field.

Cost benefit analysis
Benefit analysis is an important tool for evaluating the potential costs and benefits of a project. In this case, we perform a cost-effectiveness analysis of an IoT-based battery monitoring system for electric vehicles.
Expenses
Hardware costs: Installing an IoT-based battery monitoring system requires the purchase of hardware components such as sensors, communication devices, and data storage infrastructure.
Installation costs: The system must be installed on electric vehicles, which may require labor and special knowledge.
Maintenance and Support Costs: Ongoing maintenance and support is required to ensure proper operation of the monitoring system. Training costs: Users and technicians may require training to operate and maintain the system effectively.

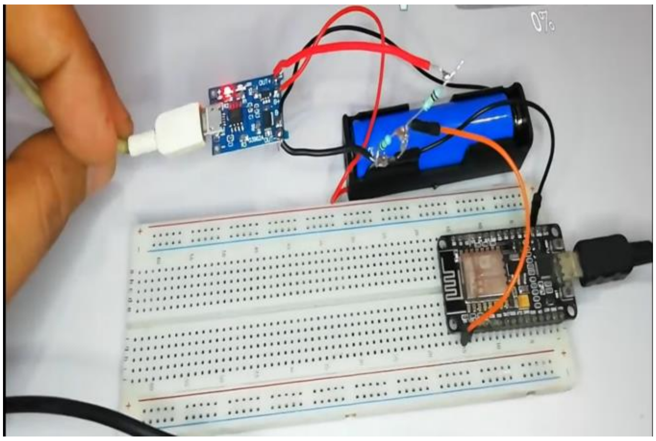

Figure 5.1 Demonstration Picture

6. CONCLUSIONS

An IoT-based battery monitoring system for electric vehicles plays a key role in ensuring the efficient and safe operation of electric vehicles. Using sensors, connectivity and data analysis, this system enables real-time monitoring of battery performance, charge and temperature.By analyzing the collected data, the system can provide valuable information about the condition of the battery, which enables preventive maintenance and optimization. This helps to extend the life of the battery, improve the overall efficiency of the electric vehicle and improve the driving experience.The IoT-based battery monitoring system also offers remote monitoring capabilities that allow vehicle owners and suppliers to access critical battery data from anywhere. This enables timely action in the event of battery anomalies or problems, which ensures uninterrupted operation and reduces the risk of interruptions.In general, the IoT-based battery monitoring system for electric vehicles is an important part of promoting electric mobility, which improves the performance, reliability and durability of electric vehicles.

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