

IOT Based Fire Prevention System For Electric Vehicle Batteries

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Abstract- Electric vehicles require intelligent monitoring to ensure safety, efficiency, and longevity. This study proposes an IoT-enabled battery monitoring and fault detection system targeting risks like overheating, voltage imbalance, and fire hazards. The framework integrates voltage, temperature, and flame sensors to capture real-time battery data. An ATmega328P microcontroller processes inputs against predefined thresholds to detect anomalies. NodeMCU enables wireless transmission to an IoT cloud for remote visualization and diagnostics. Upon fault detection, the system triggers LCD alerts and relay isolation to safeguard the battery circuit. This proactive design facilitates early intervention, minimizes downtime, and boosts reliability. Remote access empowers users and technicians for informed maintenance decisions. Cost-effective and scalable, the solution adapts to diverse EV applications. By merging embedded systems with IoT, it advances battery management, extends lifespan, and reduces fire risks. Future enhancements include predictive analytics, mobile integration, and data logging for sustainable energy utilization.

Keywords: Electric vehicles, IoT, battery management system, fault detection, NodeMCU, ATmega328P, sensors, remote monitoring, safety.

I. INTRODUCTION

Electric vehicles (EVs) are revolutionizing transportation as cleaner, more efficient alternatives to internal combustion engines. However, battery packs—the core EV component—face risks like overheating, thermal runaway, and fires due to voltage imbalances and environmental stresses. Traditional battery management systems (BMS) provide isolated, periodic checks with limited real-time visibility, often failing early fault detection.

This paper presents an IoT-enabled BMS framework using voltage, temperature, and flame sensors for continuous monitoring. Data is processed by an ATmega328P microcontroller against thresholds, with NodeMCU enabling cloud transmission for remote diagnostics. Faults trigger LCD alerts and relay isolation, promoting proactive safety, reduced

downtime, and predictive maintenance via historical analysis. Scalable and cost-effective, it extends battery life and supports sustainable EV adoption.

1.2 OBJECTIVES: The objectives align with EV safety needs:

- Design IoT-BMS for real-time battery parameter monitoring and early fault detection.
- Integrate voltage, temperature, flame sensors for cohesive data capture.
- Develop ATmega328P-based anomaly detection using thresholds.
- Implement NodeMCU for cloud connectivity and remote access.
- Enable LCD alerts and relay controls for instant hazard response.
- Ensure cost-effectiveness, scalability, and modularity across EV types.
- Lay foundation for predictive analytics and mobile integration.

1.3. PROBLEM STATEMENT: EV batteries are vulnerable to dynamic stresses (temperature/voltage fluctuations), causing overcharge, deep discharge, and thermal runaway. Legacy BMS lack real-time IoT integration, remote access, and unified sensing-processing, leading to reactive maintenance and scalability issues. Insufficient data analytics prevents trend identification and predictive.

This necessitates an advanced, IoT-driven solution for continuous tracking, early alerts, remote diagnostics, and adaptability to enhance reliability.

TRADITIONAL VS. PROPOSED BMS COMPARISON

| Feature | Traditional BMS | Proposed IoT-BMS |
|-----------------|-----------------|-------------------------------|
| Monitoring | Periodic, local | Continuous, real-time |
| Fault Detection | Reactive | Proactive (thresholds/relays) |
| Connectivity | None | Cloud/NodeMCU |

| Feature | Traditional BMS | Proposed IoT-BMS |
|-----------------|-------------------|--------------------------|
| | | remote |
| Scalability | Limited | Modular, EV-adaptable |
| Cost/Complexity | High for advanced | Low, standard components |

1.4 SCOPE: Scope includes hardware prototyping (sensors, ATmega328P, NodeMCU, LCD/relays) for voltage/temperature/flame monitoring in controlled setups. Covers cloud integration for visualization/storage and safety automation. Emphasizes affordability using off-the-shelf parts; modular for expansions. Limits: Small-scale prototypes; defers ML predictions (future work).

II. LITERATURE SURVEY

IoT-Based Lithium-Ion Battery Monitoring System in EV (2025): This study presents an IoT-based lithium-ion battery monitoring system specifically designed for electric vehicle applications, focusing on improving safety, reliability, and operational awareness. The authors emphasize the importance of continuous monitoring of battery parameters such as voltage, temperature, and state of charge to prevent battery degradation and unexpected failures. The proposed system integrates multiple sensors with a microcontroller to collect real-time data from the battery pack and transmit it to a cloud platform using IoT communication modules.

The work highlights the challenges associated with lithium-ion batteries, including thermal runaway, overcharging, and deep discharging, and addresses these issues through threshold-based monitoring and alert mechanisms. By leveraging IoT infrastructure, the system allows users and maintenance personnel to access battery data from remote locations, improving decision-making and reducing response time during abnormal condition

Experimental validation demonstrates that the system accurately detects variations in temperature and voltage under different operating conditions. The results indicate reliable communication between the sensing unit and the cloud platform, with minimal data latency.

IoT Based UPS Battery Monitoring System with Battery and Supply Changeover (2025): This paper proposes an IoT-based battery monitoring system developed for uninterruptible power supply applications, with an emphasis on intelligent battery supervision and automated supply changeover. Although primarily focused on UPS systems, the concepts and methodologies presented are highly

relevant to electric vehicle battery monitoring and energy management.

The proposed system employs voltage and current sensors to continuously track battery performance parameters. These measurements are processed using a microcontroller and transmitted to a cloud-based IoT platform for visualization and analysis. One of the notable contributions of this work is the automated battery and power supply changeover mechanism, which ensures uninterrupted operation during abnormal battery conditions.

The authors demonstrate how IoT integration enhances system reliability by enabling predictive maintenance and early fault detection. Alerts and notifications are generated when battery parameters exceed predefined thresholds, allowing timely intervention.

Experimental results validate the effectiveness of the system in accurately detecting voltage drops and battery failures. The communication framework shows reliable data transmission with low latency, making it suitable for real-time applications. The modular design of the system allows scalability and adaptability to different battery capacities and operational requirements.

In conclusion, this work illustrates how IoT technologies can transform conventional battery monitoring systems into intelligent, automated solutions. While the application domain is UPS systems.

Revolutionizing Battery Maintenance Through IoT-based Inverter Monitoring for Smart Energy Systems (2025): This research introduces an IoT-based inverter and battery monitoring framework aimed at improving battery maintenance in smart energy systems. The authors focus on addressing the limitations of traditional battery maintenance approaches, which often rely on periodic inspections and lack real-time diagnostic capabilities. By integrating IoT technologies, the proposed system enables continuous monitoring of inverter and battery parameters, ensuring improved operational reliability and system longevity.

The system architecture includes sensors for measuring voltage, current, and temperature, which are interfaced with a microcontroller for data processing. The collected data is transmitted to a cloud platform, allowing users to monitor system performance remotely. The authors highlight that real-time monitoring plays a crucial role in identifying early signs of battery degradation, thus preventing severe failures and reducing maintenance costs.

The experimental analysis confirms the reliability of the system in detecting performance deviations and maintaining stable communication with the cloud server. The authors report improved system transparency and reduced downtime as key outcomes of the proposed solution. The modular design allows easy integration with existing energy infrastructures, making it applicable to a wide range of smart grid and renewable energy applications.

Overall, this study demonstrates the transformative impact of IoT on battery maintenance practices. Although the primary focus is on inverter-based energy systems.

Revolutionizing Battery Maintenance Through IoT-based Inverter Monitoring for Smart Energy Systems (2025): This study further explores IoT-based inverter monitoring as a means to revolutionize battery maintenance in intelligent energy environments. The authors focus on leveraging continuous data acquisition and cloud-based analytics to enhance battery performance monitoring and fault diagnosis. The proposed framework aims to overcome the shortcomings of conventional monitoring systems by providing real-time insights into battery health and inverter operation.

The system employs multiple sensors to capture critical electrical and thermal parameters, which are processed by an embedded controller. Through IoT connectivity, the data is uploaded to a remote server where it can be accessed through user-friendly dashboards. This enables operators to monitor system status without physical presence, improving operational efficiency and safety.

A key strength of this work lies in its emphasis on predictive maintenance. By analyzing historical data trends, the system supports early identification of abnormal patterns, reducing the likelihood of sudden failures. The authors highlight that such predictive capabilities are essential for applications involving continuous power delivery and energy storage. Testing results demonstrate stable system operation and accurate fault detection under varying load conditions.

In summary, this research reinforces the potential of IoT technologies in enhancing battery maintenance strategies. Although the application context is smart energy systems, the methodologies and findings are directly relevant to electric vehicle battery monitoring. The work provides valuable insights into designing intelligent, connected monitoring solutions that improve reliability, safety, and maintenance efficiency in modern energy storage systems.

IoT based Battery Storage Temperature Monitoring System (2022): This paper presents an IoT-based temperature monitoring system developed specifically for battery storage applications, emphasizing thermal safety and real-time supervision. The authors identify temperature as a critical parameter influencing battery performance, lifespan, and safety, particularly in energy storage and electric vehicle systems. The proposed solution aims to detect abnormal temperature rise at an early stage to prevent hazardous events such as thermal runaway.

The study includes experimental testing under different environmental and operational scenarios. Results show that the system accurately tracks temperature variations and provides timely alerts when predefined thresholds are exceeded.

A key contribution of this work is its focus on thermal management rather than comprehensive battery diagnostics. By isolating temperature as a primary safety parameter, the system provides a focused and reliable monitoring solution. The authors also discuss the potential integration of the system with broader battery management frameworks to enhance overall safety.

In conclusion, this research demonstrates the effectiveness of IoT-based temperature monitoring in improving battery safety and reliability. While the system targets stationary battery storage, its principles are directly applicable to electric vehicle battery packs. The study reinforces the importance of real-time thermal monitoring as a fundamental component of intelligent battery management systems and provides a practical reference for future IoT-based safety solutions.

Battery Monitoring System on IoT-Based Smart Micro Grid (2024): This paper presents the design and implementation of an IoT-based battery monitoring system within a smart microgrid environment, emphasizing efficient energy management and system reliability. The authors focus on the growing need for intelligent monitoring solutions as distributed energy resources and battery storage systems become integral components of modern power grids. The proposed system aims to provide real-time visibility into battery operating conditions, supporting stable microgrid operation and informed energy management decisions.

One of the key contributions of this work is its application within a smart microgrid context, where batteries experience dynamic load variations and intermittent renewable energy inputs. The IoT-based approach enables adaptive monitoring and supports proactive maintenance strategies by

detecting abnormal operating conditions at an early stage. Visual dashboards and alert mechanisms enhance system transparency and allow quick responses to faults. Experimental evaluation confirms that the system provides accurate and stable measurements under varying operating conditions.

In conclusion, this study demonstrates the effectiveness of IoT-based battery monitoring in smart microgrid applications. Although focused on stationary energy systems, the methodologies and findings are directly applicable to electric vehicle battery management.

Development of IoT Based Battery Management System for EV (2024): This research focuses on the development of an IoT-based battery management system specifically designed for electric vehicle applications. The authors emphasize the critical role of battery management in ensuring vehicle safety, performance, and longevity. The proposed system addresses limitations of conventional battery monitoring techniques by incorporating real-time data acquisition and remote monitoring capabilities through IoT technologies.

The system architecture includes sensors for measuring key battery parameters such as voltage, current, and temperature. These sensors are interfaced with a microcontroller that processes the data and transmits it to a cloud-based platform using wireless communication modules. The authors highlight that real-time monitoring allows early detection of abnormal conditions, including overcharging, overheating, and excessive discharge, which are common causes of battery failure in electric vehicles.

A significant contribution of this work is its focus on user accessibility and system scalability. The cloud interface provides real-time visualization of battery parameters and generates alerts when threshold limits are exceeded.

Overall, this study highlights the practical benefits of integrating IoT technologies into electric vehicle battery management systems. The findings confirm that IoT-based monitoring enhances safety, reduces maintenance costs, and improves battery lifespan.

A Real-time Performance Monitoring of IoT-based on Lithium-Ion Battery Pack (2024): This paper presents a real-time performance monitoring system for lithium-ion battery packs using IoT technology, with a focus on enhancing operational safety and performance awareness. The authors recognize lithium-ion batteries as critical components in electric vehicles and energy storage systems,

where continuous monitoring is essential to prevent failures and optimize usage.

The system utilizes sensors to measure voltage, current, and temperature across the battery pack. These measurements are processed by an embedded controller and transmitted to an IoT platform for remote access and visualization. The authors emphasize that real-time monitoring enables timely identification of abnormal trends, such as excessive temperature rise or voltage imbalance, which can lead to reduced battery life or safety hazards.

Experimental testing is conducted to evaluate system performance under different charging and discharging scenarios. The results demonstrate accurate parameter measurement and reliable data transmission to the cloud platform. The authors also highlight the importance of graphical visualization tools in helping users understand battery performance trends and make informed operational decisions.

In conclusion, this research demonstrates the effectiveness of IoT-based real-time monitoring in improving lithium-ion battery performance and safety. Although the study is not limited to electric vehicles, the concepts and system design are directly applicable to EV battery packs.

Monitoring the Battery Health in Electric Vehicles through IoT (2024): This paper explores an IoT-based approach for monitoring battery health in electric vehicles, with the objective of improving reliability, safety, and maintenance efficiency. The authors highlight battery health as a decisive factor influencing vehicle performance, driving range, and user confidence. The proposed system addresses the need for continuous and accurate monitoring of battery parameters in real-world operating conditions.

The system architecture incorporates sensors to measure voltage, temperature, and current, which are connected to a microcontroller for data processing. IoT connectivity enables the transmission of collected data to a cloud-based platform, allowing remote monitoring and analysis. The authors emphasize that cloud integration facilitates long-term data storage and trend analysis, supporting predictive maintenance strategies.

A notable aspect of this study is its focus on battery health estimation rather than only real-time monitoring. By analyzing historical data patterns, the system provides insights into battery aging and degradation trends.

In summary, this work demonstrates the effectiveness of IoT-based battery health monitoring in electric vehicles. The proposed solution enhances operational transparency, reduces maintenance effort, and supports informed decision-making.

IoT Based Battery Monitoring System (2022): This study presents an IoT-based battery monitoring system aimed at improving battery supervision and maintenance efficiency across various applications. The authors focus on the limitations of traditional battery monitoring methods, which often rely on manual inspection and lack real-time diagnostic capability. The proposed system leverages IoT technology to enable continuous monitoring and remote access to battery performance data.

The system design includes sensors for measuring voltage, current, and temperature, interfaced with a microcontroller for data processing. Using wireless communication, the system transmits real-time data to an IoT platform where it can be visualized and analyzed. The authors highlight that real-time monitoring helps identify abnormal conditions early, reducing the risk of battery failure and extending battery lifespan.

Experimental evaluation demonstrates reliable system operation and accurate measurement of battery parameters. The communication framework shows stable connectivity and effective data transmission. The authors also discuss the simplicity and cost-effectiveness of the system, making it suitable for small-scale deployments and educational applications.

In conclusion, this research confirms that IoT-based battery monitoring systems offer significant advantages over conventional approaches. The proposed system improves safety, reliability, and maintenance efficiency through real-time sensing and remote supervision. The work provides a foundational reference for future research in IoT-enabled battery management and supports the adoption of intelligent monitoring technologies in emerging energy and transportation systems.

III. EXISTING SYSTEM

The existing systems used for monitoring electric vehicle batteries primarily rely on conventional battery management techniques that focus on basic parameter measurement and control. These systems are generally designed to supervise voltage, current, and temperature within predefined limits to ensure safe operation. While they provide essential protection, their functionality is often limited to

onboard processing without advanced connectivity or intelligent analysis capabilities. As a result, their ability to detect complex faults or predict potential failures remains constrained.

Most traditional battery management systems operate in a closed environment, where data is processed locally and not shared beyond the vehicle. This lack of external communication restricts real time monitoring and prevents users or technicians from accessing battery information remotely. Consequently, maintenance decisions are often based on periodic inspections rather than continuous observation, which can lead to delayed identification of issues. In many cases, faults are only detected after noticeable performance degradation or system failure occurs.

Another limitation of existing systems is their dependency on threshold-based detection methods. Although these methods are effective for identifying extreme conditions, they may not capture gradual changes or subtle anomalies that indicate early stages of failure. This reduces the overall efficiency of fault detection and increases the risk of unexpected breakdowns. Additionally, many systems do not include integrated fire detection mechanisms, which are crucial for preventing hazardous situations in high energy battery environments.

Cost and complexity are additional challenges in some existing solutions, particularly those designed for high end electric vehicles. Advanced battery management systems may offer improved features but are often expensive and not easily adaptable to smaller or low-cost vehicle models. This creates a gap in accessibility, where efficient monitoring solutions are not widely available across all segments of electric mobility.

In summary, the existing systems provide fundamental battery protection but lack the intelligence, connectivity, and flexibility required for modern electric vehicles. Their limitations in real time monitoring, remote access, early fault detection, and data analysis highlight the need for more advanced solutions. Addressing these gaps is essential to improving safety, enhancing performance, and supporting the continued growth of electric vehicle technology.

Disadvantages

- Limited real-time monitoring capabilities, leading to delayed detection of faults.
- Lack of remote access, restricting users from monitoring battery status externally.

- Dependence on basic threshold-based detection, which cannot identify early-stage anomalies.
- Absence of IoT integration, reducing system intelligence and connectivity.
- Inadequate fire detection mechanisms, increasing safety risks.
- Minimal user interface and feedback, providing insufficient diagnostic information.
- No proper data logging or historical analysis for performance evaluation.
- Higher cost in advanced systems, making them less accessible for low-cost EVs.
- Poor scalability and difficulty in adapting to different vehicle types.
- Limited ability to support predictive maintenance and advanced analytics.

IV. PROPOSED SYSTEM

The proposed system introduces an advanced IoT based battery monitoring and fault detection framework designed to enhance the safety, efficiency, and reliability of electric vehicles. Unlike conventional approaches, this system integrates sensing, processing, and communication technologies into a unified architecture that enables continuous real time observation of battery conditions. The primary aim is to identify potential faults at an early stage and provide

immediate alerts to prevent hazardous situations.

The system incorporates multiple sensors, including voltage, temperature, and fire detection units, to capture critical parameters affecting battery performance. These sensors are strategically connected to a microcontroller that processes the incoming data and evaluates it against predefined safety thresholds. By continuously analyzing these parameters, the system can detect abnormalities such as overheating, voltage fluctuations, or signs of combustion, ensuring timely intervention.

A key feature of the proposed design is the integration of a wireless communication module that facilitates seamless data transmission to an IoT cloud platform. This enables remote monitoring, allowing users and technicians to access real time battery information from any location. The cloud interface provides a clear visualization of system status, helping in better understanding and decision making. This level of connectivity significantly improves accessibility and operational awareness.

The proposed system is designed with scalability and flexibility in mind, making it suitable for different types of

electric vehicles. Its modular architecture allows easy integration of additional sensors or features without major modifications. The use of cost-effective components ensures that the solution remains affordable while maintaining high performance standards.

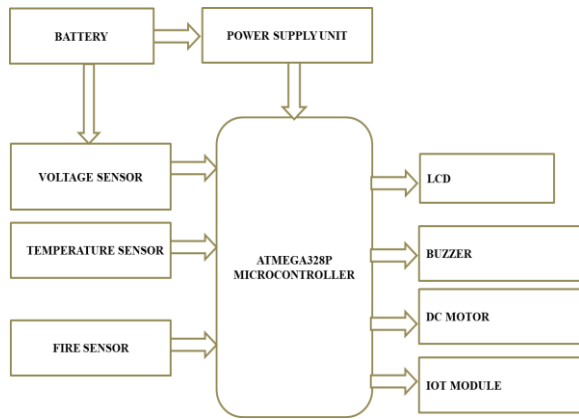
Another important aspect of the system is its ability to support data storage and analysis. By maintaining records of battery performance, it becomes possible to identify trends and optimize usage patterns. Although advanced predictive techniques are not the primary focus, the system provides a foundation for future enhancements in intelligent analytics and maintenance strategies.

Overall, the proposed system offers a comprehensive solution to the limitations of existing battery monitoring methods. By combining real time sensing, IoT connectivity, and automated safety mechanisms, it ensures improved performance and reduced risk. This approach contributes to the development of smarter electric mobility solutions and supports the growing demand for safe and efficient transportation systems.

Advantages

- Enables real-time monitoring of battery parameters for immediate status updates.
- Provides early fault detection, reducing the risk of severe damage and failures.
- Supports remote access through IoT, allowing monitoring from anywhere.
- Enhances safety with integrated fire and temperature detection mechanisms.
- Triggers instant alerts and automated responses during abnormal conditions.
- Improves battery lifespan through continuous condition tracking and control.
- Offers cost-effective implementation using readily available components.
- Allows scalability and easy integration with different types of electric vehicles.
- Facilitates data logging for performance analysis and future improvements.
- Increases overall system reliability and user confidence in electric vehicle operation.

BLOCK DIAGRAM



BLOCK DIAGRAM DESCRIPTION

The block diagram represents an IoT based battery monitoring and fault detection system designed for electric vehicle applications. It illustrates the interaction between sensing units, processing components, output devices, and communication modules to ensure efficient and safe battery operation. The system is structured around the ATmega328P microcontroller, which acts as the central processing unit responsible for coordinating all activities.

The battery serves as the primary power source in the system. It supplies energy to the power supply unit, which regulates and distributes appropriate voltage levels to different components. This regulation is essential to ensure stable operation and prevent damage to sensitive electronic elements. The power supply unit also provides consistent input to the microcontroller and connected peripherals, maintaining system reliability under varying conditions.

To monitor battery health, multiple sensors are integrated into the system. The voltage sensor continuously measures the battery voltage and sends corresponding signals to the microcontroller. This helps in identifying conditions such as overvoltage or undervoltage, which can affect performance and lifespan. Alongside this, the temperature sensor tracks thermal variations within the battery environment. Temperature is a critical parameter, as excessive heat can lead to reduced efficiency or hazardous situations. The fire sensor adds an additional layer of safety by detecting the presence of flames or abnormal heat patterns, enabling early identification of potential fire risks.

All sensor outputs are directed to the ATmega328P microcontroller, where the data is processed and analyzed. The microcontroller compares incoming values with predefined safety thresholds to determine whether the system is operating under normal or abnormal conditions. Based on

this evaluation, appropriate actions are initiated to maintain safety and efficiency.

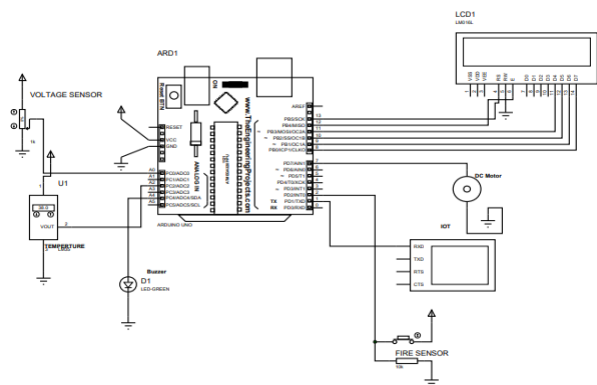
The system includes several output components to provide feedback and control. The LCD display presents real time information such as voltage levels, temperature readings, and system status. This visual representation allows users to easily monitor battery conditions. The buzzer functions as an alert mechanism, generating audible warnings when abnormal parameters are detected. This ensures immediate attention even if the display is not being actively observed.

A DC motor is incorporated in the diagram to represent a load or operational component powered by the battery. The microcontroller can control this motor based on system conditions, such as stopping its operation during fault scenarios to prevent further damage. This demonstrates the system’s ability to not only monitor but also actively manage connected devices.

The IoT module plays a crucial role in enabling wireless communication. It connects the system to cloud platforms, allowing data to be transmitted for remote monitoring and analysis. Users can access this data from anywhere, improving accessibility and enabling timely decision making. This feature enhances the overall functionality by extending monitoring capabilities beyond the physical system.

Overall, the block diagram depicts a well-integrated system that combines sensing, processing, control, and communication. Each component works collaboratively to ensure continuous monitoring, rapid fault detection, and effective response. The design highlights a practical approach to improving battery safety, optimizing performance, and supporting modern electric vehicle requirements through IoT technology.

CIRCUIT DIAGRAM



CIRCUIT DIAGRAM DESCRIPTION

The circuit diagram represents the detailed electrical connections of an IoT based battery monitoring and fault detection system designed for electric vehicle applications. It illustrates how individual components are interconnected to perform sensing, processing, control, and communication functions in a coordinated manner. The ATmega328P microcontroller forms the core of the circuit, acting as the central unit that manages input signals and generates appropriate outputs.

The power supply section is responsible for delivering regulated voltage to all components in the circuit. It typically consists of a voltage regulator that converts the battery output into a stable level suitable for the microcontroller and peripheral devices. Proper grounding and filtering elements such as capacitors are included to reduce noise and ensure consistent performance.

The voltage sensor is connected to the battery through a voltage divider network, which scales down the battery voltage to a level that can be safely read by the microcontroller's analog input pins. This allows continuous monitoring of battery voltage without damaging the controller. Similarly, the temperature sensor is interfaced with the microcontroller using analog or digital input pins, depending on the sensor type.

The fire sensor is integrated into the circuit to enhance safety by identifying flame or excessive heat presence. Its output is connected to one of the microcontroller input pins, enabling immediate detection of hazardous situations. All sensor signals are processed by the microcontroller, which compares them with predefined threshold values stored in its program memory.

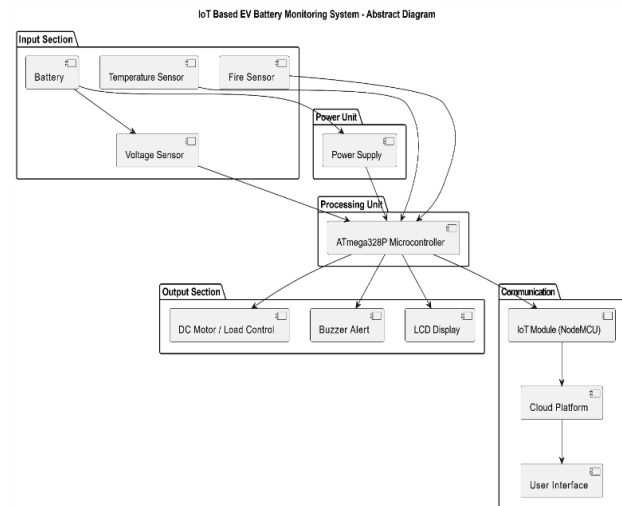
Output components are connected to the microcontroller through appropriate interfacing circuits. The LCD display is typically interfaced using digital pins, often in 4 bit or 8-bit mode, to show real time system parameters such as voltage, temperature, and alert messages. Current limiting resistors are used where necessary to protect the display and ensure proper functioning.

The buzzer is connected through a transistor driver circuit, allowing the microcontroller to activate it when abnormal conditions are detected. This ensures that sufficient current is supplied for audible alerts without overloading the microcontroller pins.

The IoT module, such as NodeMCU, is interfaced with the microcontroller using serial communication protocols. Voltage level compatibility is maintained through proper interfacing techniques to ensure reliable data exchange. This module transmits sensor data to cloud platforms, enabling remote monitoring and analysis.

Overall, the circuit diagram demonstrates a well-structured integration of electronic components, ensuring efficient data flow and system control. Each connection is designed to support accurate sensing, stable operation, and effective response mechanisms. The circuit provides a practical foundation for implementing a reliable battery monitoring system with enhanced safety, real time feedback, and IoT based connectivity for modern electric vehicle applications.

FLOW CHART



FLOW CHAT DESCRIPTION

The flow chart of the proposed system represents the logical sequence of operations involved in monitoring and protecting the battery of an electric vehicle using IoT technology. It begins with system initialization, where all hardware components such as sensors, microcontroller, display unit, and communication module are powered and configured. During this stage, the microcontroller sets predefined threshold values for voltage, temperature, and fire detection to ensure proper decision making throughout the process.

Once initialization is complete, the system enters a continuous monitoring loop. In this phase, the voltage sensor measures the battery voltage, while the temperature sensor records the thermal condition of the battery environment.

Simultaneously, the fire sensor checks for any indication of flame or abnormal heat.

The next step in the flow involves data processing and comparison. The microcontroller evaluates the incoming sensor data against predefined safe limits. If all parameters remain within acceptable ranges, the system continues normal operation. The current status, including voltage and temperature values, is displayed on the LCD screen for user awareness. Additionally, the same data is transmitted to the IoT module, which sends it to a cloud platform for remote monitoring and record keeping.

If any parameter exceeds the defined threshold, the system identifies it as an abnormal condition and initiates corrective actions. In such cases, the flow chart directs the system to trigger an alert mechanism. The buzzer is activated to provide an audible warning, and the LCD display shows a fault message indicating the type of issue detected. This immediate feedback ensures that users are quickly informed about potential risks.

Following the alert stage, the system proceeds to control actions aimed at preventing further damage. The microcontroller may deactivate or regulate the connected load, such as stopping the DC motor or isolating the battery using a relay mechanism. This step is crucial in minimizing the impact of hazardous conditions and maintaining system safety.

After executing the required actions, the system does not stop but continues monitoring in a loop. It repeatedly checks whether the parameters return to normal conditions. If the issue is resolved, the system resumes standard operation and updates the display and cloud data accordingly. If the abnormal condition persists, the alert and control mechanisms remain active.

Overall, the flow chart illustrates a systematic and dynamic process that combines sensing, analysis, alerting, and control. It ensures that the battery is continuously monitored and protected through timely detection and response. This structured flow enhances safety, improves reliability, and supports efficient operation of electric vehicle systems using IoT technology.

V. RESULT

The implemented IoT based battery monitoring and fault detection system demonstrates effective performance in tracking and managing critical parameters of an electric vehicle battery. The system successfully monitors voltage, temperature, and fire related conditions in real time using

integrated sensors. The ATmega328P microcontroller processes the sensor data accurately and continuously, ensuring that even minor deviations from normal operating conditions are identified without delay.

During testing, the voltage sensor provided consistent readings that reflected the battery status under different load conditions. The temperature sensor effectively captured variations in thermal levels, particularly during simulated stress scenarios. The fire sensor responded promptly to abnormal heat or flame indications, validating its role in enhancing safety. These sensing elements worked in coordination, enabling a comprehensive understanding of battery behavior.

The LCD display functioned reliably by presenting real time data, including voltage levels, temperature readings, and system status messages. This allowed users to easily interpret the condition of the battery without requiring additional tools. In situations where abnormal parameters were detected, the buzzer alert system activated immediately, providing a clear and timely warning signal.

Users were able to access real time updates and system alerts through connected interfaces, improving accessibility and convenience. Data logging functionality allowed storage of system parameters, which can be used for future analysis and performance evaluation. The system maintained stable operation throughout the testing phase, demonstrating reliability and efficiency.

Overall, the results confirm that the proposed system achieves its objective of providing continuous monitoring, early fault detection, and immediate response. It enhances battery safety, improves operational control, and supports remote supervision, making it a practical solution for modern electric vehicle applications.

Description

The performance of the proposed system highlights the significance of integrating IoT technology with battery monitoring frameworks in electric vehicles. The ability to continuously observe key parameters and respond instantly to abnormal conditions represents a major improvement over traditional system. The combination of multiple sensors ensures that different aspects of battery health are evaluated simultaneously, reducing the chances of undetected faults.

One of the key observations is the effectiveness of real time monitoring in preventing critical failures. By detecting issues such as overheating or voltage fluctuations at an early stage, the system allows timely intervention, which is

essential for maintaining safety and reliability. The inclusion of a fire sensor further strengthens the system by addressing one of the most serious risks associated with battery operation.

The role of the microcontroller in processing and decision making is crucial. Its ability to compare sensor data with predefined thresholds ensures accurate identification of abnormal conditions. However, the system currently relies on fixed threshold values, which may not always adapt to dynamic operating environments. This suggests an opportunity for future enhancement through adaptive or intelligent algorithms.

The integration of IoT connectivity adds significant value by enabling remote access and data visualization. Users are no longer limited to physical monitoring, which improves convenience and expands the scope of system supervision. This feature also supports data logging, which can be utilized for analyzing trends and improving maintenance strategies.

In conclusion, the discussion emphasizes that the proposed system offers a reliable and efficient approach to battery monitoring. It successfully addresses key challenges in safety and performance while providing a foundation for future advancements in smart electric vehicle technologies.

VI. CONCLUSION

The proposed IoT based battery monitoring and fault detection system presents a reliable and efficient approach to improving the safety and performance of electric vehicles. By integrating multiple sensors, embedded processing, and wireless communication, the system ensures continuous observation of critical battery parameters such as voltage, temperature, and fire conditions. This comprehensive monitoring capability enables early detection of abnormalities, reducing the likelihood of severe failures and hazardous incidents.

The use of the ATmega328P microcontroller allows accurate data processing and decision making based on predefined safety thresholds. The system effectively identifies deviations and responds through alert mechanisms and control actions, ensuring that risks are minimized in real time. The inclusion of visual and audible indicators enhances user awareness, making it easier to understand system conditions and take appropriate measures when required.

One of the significant advantages of the system is its ability to provide remote monitoring through IoT connectivity. The integration of the NodeMCU module enables seamless communication with cloud platforms, allowing users to access

battery data from any location. This feature improves convenience and supports timely decision making, especially in critical situations. Additionally, the ability to store and review data contributes to better analysis and understanding of battery performance over time.

The system also demonstrates cost effectiveness and scalability, making it suitable for various types of electric vehicles. Its modular design allows easy integration with existing systems and provides flexibility for future upgrades. By reducing dependency on manual inspection and enabling automated monitoring, the system enhances operational efficiency and reliability.

Overall, the project successfully addresses key challenges associated with battery safety and management in electric vehicles. It provides a practical solution that combines real time monitoring, intelligent response, and remote accessibility. This contributes to the advancement of smart electric mobility and supports the transition toward safer and more sustainable transportation systems.

VII. FUTURE ENHANCEMENT

The proposed system provides a strong foundation for further development and integration of advanced technologies to enhance its functionality and performance. One of the primary areas for future enhancement is the incorporation of intelligent data analysis techniques such as machine learning and predictive algorithms. These methods can enable the system to identify patterns, predict potential failures, and provide early warnings before faults occur, improving overall reliability.

Another important enhancement involves improving sensor accuracy and expanding the range of monitored parameters. Additional sensors can be integrated to measure factors such as current, state of charge, and environmental conditions. This would provide a more comprehensive understanding of battery behavior and support better decision making. Advanced sensor calibration techniques can also be applied to ensure consistent and precise measurements.

The communication capabilities of the system can be further enhanced by integrating more robust and secure IoT protocols. This would improve data transmission reliability and protect sensitive information from unauthorized access. The development of dedicated mobile or web applications can provide a more user-friendly interface, allowing users to monitor system status, receive notifications, and control operations more efficiently.

Scalability can also be improved to support large scale deployment in commercial electric vehicles and fleet management systems. This would require optimization of hardware and software components to handle increased data volume and ensure stable performance under complex conditions. Integration with smart grid systems and energy management platforms can further extend the application scope.

Energy efficiency is another area that can be optimized by designing low power hardware components and implementing power saving algorithms. This would reduce the overall energy consumption of the monitoring system and enhance sustainability.

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