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IOT Based Safe Charge Adapter Guard

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***Abstract*—Safe battery charging is an essential aspect in modern electronic and energy storage systems because excessive heat during charging can reduce battery life and create safety hazards. This research presents a temperature-based battery protection system developed using the NodeMCU ESP8266 microcontroller, DHT11 temperature sensors, and a relay module. The system continuously observes the temperature of multiple batteries during the charging process. When the measured temperature rises above a specified threshold, the relay automatically disconnects the charging supply to avoid overheating. This automatic protection mechanism improves battery safety, reliability, and performance. The proposed design is cost-effective, easy to implement, and suitable for applications such as electric vehicles, portable electronics, and backup power systems. The project demonstrates how simple IoT-based monitoring and control can enhance charging safety in battery-operated devices.**

***Index Terms*—Internet of Things (IoT), Safe charge, Temperature control, Real-time monitoring, Automatic cut-off**

I. INTRODUCTION

Lithium-ion batteries are extensively utilized in electric vehicles, portable electronics, and renewable energy storage systems because of their high energy density, long cycle life, and efficient performance. However, during charging and discharging, batteries generate heat that can increase cell temperature and reduce battery life. Excessive temperature may also lead to safety issues such as overheating and thermal runaway. Therefore, maintaining battery temperature within a safe operating range is crucial for securing protection, immunity, reliability, and better performance.
This research presents the evolution of a battery charging safety system using a NodeMCU ESP8266, DHT11 temperature sensors, and a relay module. The general system continuously oversees battery temperature and automatically disconnects the charging supply when the temperature exceeds a predefined limit. The system is intended to improve battery safety and can be implemented in electric vehicles, backup power systems, and portable electronic devices. By providing real-time thermal

monitoring and protection, the proposed approach supports safer and more sustainable energy storage technologies.

Background and motivation for the project

The increasing acceptance of electric vehicles (EVs) and portable electronics has led to a surge in demand for safe and reliable charging solutions. However, conventional charging systems often lack real-time monitoring and protection mechanisms, posing risks of electrical fires, overcharging, and thermal runaway. According to recent incidents, faulty charging adapters and inadequate safety measures have contributed to numerous accidents, highlighting the need for smarter, safer charging technologies.

An IOT-based safe charging adapter guard addresses these concerns by integrating sensors, connectivity, and automation to monitor charging parameters, detect anomalies, and prevent hazards. This project leverages IOT capabilities to create a proactive safety layer for charging systems, ensuring user safety and device protection.

II. MOTIVATION

- Growing EV market and portable device usage:

The convergence of booming Electric Vehicle (EV) adoption and ubiquitous portable device usage has created an unprecedented surge in demand for lithium-ion batteries, transforming global energy storage markets.

- Rising safety concerns due to charging-related accidents:

Including thermal runaway, battery fires, and electric shocks—are creating significant consumer anxiety and hindering rapid adoption.

- Need for smart, connected safety solutions:

They bridge physical and digital safety, offering immediate situational awareness, reducing insurance costs, and ensuring worker/resident well-being.

- Opportunity to integrate IOT for real-time protection:

It offers a significant opportunity for real-time, proactive protection and enhanced operational efficiency in military and surveillance applications.

III. PROBLEM STATEMENT

The increasing use of electronic devices and lithium-ion batteries has created safety concerns during charging. Problems such as overheating, damaged cables, voltage fluctuations, and low-quality charging adapters can reduce battery life and cause hazards like short circuits, electric shocks, and fire risks. In many systems, proper temperature monitoring and protection are not available. Therefore, a smart battery charging safety system is needed to monitor temperature and automatically disconnect the power supply during unsafe conditions to ensure safe and reliable charging.

IV.OBJECTIVES

- Provide safe battery charging by preventing overheating, overcharging, and short-circuit problems.
- Continuously monitor battery temperature, battery voltage, and current using IoT technology.
- Automatically disconnect the power source when unsafe charging conditions are detected.
- To notifies users about abnormal conditions through alerts or notifications.
- Reduce unnecessary power usage by stopping charging after the battery is fully charged.
- To store charging data for future monitoring, analysis, and better battery performance management.

V. LITERATURE REVIEW

IoT-enabled smart battery switching system for electric two-wheelers to improve efficiency, reliability, and sustainable transportation. The system continuously oversees battery performance using voltage sensors and an ATmega328 microcontroller. When the primary battery voltage drops below a set limit, the controller automatically shifts the power supply to a solar-assisted backup battery, ensuring uninterrupted vehicle operation. An LCD module provides real-time battery information, while IoT connectivity allows remote monitoring and maintenance. By integrating intelligent battery management with renewable solar energy, the system minimizes dependence on conventional charging infrastructure, enhances energy utilization, and offers an eco-friendly solution for modern urban mobility. [1]

The paper discusses the design and implementation of a dual-input DC-DC converter intended for solar energy applications to improve power conversion efficiency and energy management. The proposed converter enhances the utilization of renewable energy sources and supports reliable power supply in modern electrical systems.[2]

IoT-based battery management systems used for electric vehicles, focusing on system architectures, monitoring techniques, communication technologies, and industrial applications. It highlights how IoT integration improves battery performance, safety, real-time monitoring, and predictive maintenance in modern electric vehicle systems.[3]

The study focuses on specializing machine learning methods and techniques, particularly Decision Tree and CatBoost algorithms, for battery health monitoring and prediction. The proposed approach improves battery performance analysis, fault detection, and predictive maintenance, assisting to improved the reliability and lifespan of energy storage systems used in electric vehicles and renewable energy applications.[4]

The evolution of an intelligent Battery Management System (BMS) capable of real-time tracking and fault detection for energy storage systems. The proposed architecture improves battery safety, reliability, and operational efficiency by continuously tracking battery parameters and identifying faults at an early stage. The study draw attention to the importance of smart monitoring techniques in enhancing the performance and lifespan of batteries used in electric vehicles and renewable energy applications.[5]

VI. GAP ANALYSIS

Gap identification in an IoT-based safe charge adapter guard system becomes clear when you compare what current designs actually do versus what a robust, real-world safety system should achieve. Most existing implementations focus on basic protection logic such as cutting off power when temperature or voltage exceeds a threshold, but they fall short of delivering a truly intelligent, adaptive, and secure charging environment.

One of the most prominent gaps lies in the absence of predictive intelligence. Current systems are largely reactive, meaning they respond only after unsafe conditions such as overheating or overvoltage have already occurred. This approach limits effectiveness because damage or degradation may have already begun by the time the system intervenes. A more advanced system should anticipate unsafe trends using historical data, charging patterns, and environmental conditions, but such predictive capabilities are rarely implemented in low-cost IoT charging solutions.

Another critical gap is the lack of adaptability across different battery types and devices. Most research prototypes are designed for a specific application, such as a single lithium-ion battery pack or a particular device category. In practice, users connect a wide variety of devices with different charging characteristics, capacities, and safety limits. Existing systems do not dynamically adjust their control parameters based on the connected load, which restricts their usability and effectiveness in real-world scenarios where universality is essential.

Finally, scalability and deployment challenges remain largely unaddressed. Many proposed solutions are tested only in laboratory environments and do not consider large-scale deployment issues such as cost, interoperability, maintenance, and compatibility with existing electrical infrastructure. Without addressing these aspects, it becomes difficult to transition from prototype to real-world application.

In summary, the gap in IoT-based safe charge adapter guard systems is not due to a lack of basic functionality but rather the absence of a holistic approach. Current systems need to evolve toward predictive, adaptive, secure, and user-centric designs that integrate edge intelligence, robust communication, and scalable architecture to meet real-world safety and performance requirements.

VII. METHODOLOGY

The proposed system is designed to improve battery charging safety by monitoring temperature conditions during charging. The system uses a NodeMCU ESP8266 microcontroller DHT11 temperature sensor, relay module, power adapter, and battery pack.

Initially, the AC power supply is converted into suitable DC power using a power adapter to charge the battery. The DHT11 sensor is placed near the battery to continuously measure the temperature during the charging process. The sensor sends real-time temperature data to the NodeMCU

ESP8266 controller.

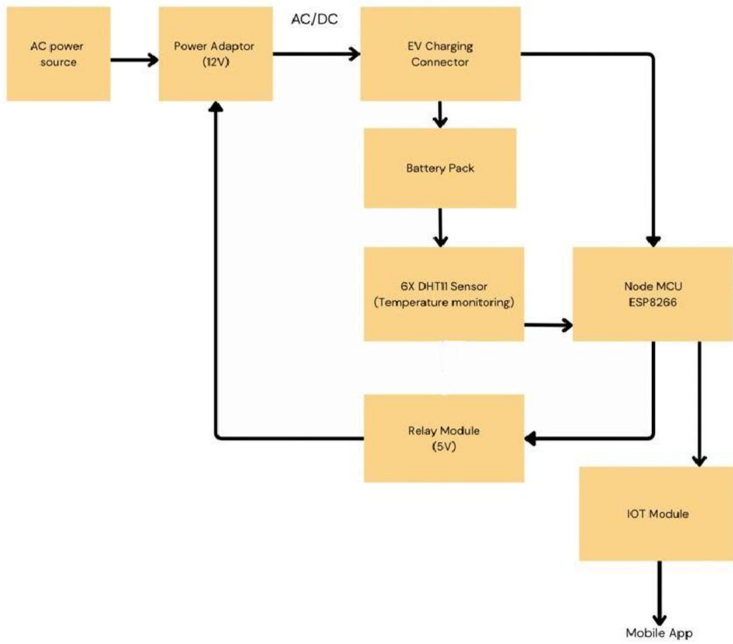

Fig. a) Block diagram

The microcontroller continuously compares the measured temperature with a predefined safe temperature limit. If the temperature remains within the safe range, the charging process continues normally. When the temperature exceeds the set limit, the NodeMCU sends a signal to the relay module to automatically disconnect the power supply and stop charging. This helps prevent overheating, battery damage, and possible safety hazards.

The system can also display or transmit monitoring data through IoT connectivity for real-time observation and analysis. By combining temperature monitoring, automatic protection, and IoT-based control, the proposed methodology ensures safe and reliable battery charging operation.

VIII. RESULT AND DISCUSSION

The developed battery charging safety system was successfully tested using the NodeMCU ESP8266, DHT11 temperature sensor, and relay module. During the charging process, the DHT11 sensor continuously monitored the battery temperature and sent real-time data to the microcontroller. The system operated normally when the battery temperature remained within the safe limit**.**

When the temperature exceeded the predefined threshold value, the NodeMCU automatically activated the relay module to disconnect the charging supply. This prevented further temperature rise and protected the battery from overheating and possible damage. The response of the system was quick and reliable during testing.

The results show that the projected system can productively enhanced charging safety by providing

continuous temperature monitoring and automatic protection control. The IoT-based monitoring feature also allowed easy observation of battery conditions in real time. In addition, the system reduced unnecessary power usage by stopping the charging process during unsafe conditions.
Overall, the proposed model is simple, low-cost, and suitable for applications such as electric vehicles, backup power systems, and portable electronic devices. The project demonstrates that integrates the Internet of Things (IoT) technology with thermal monitoring can improve battery safety, reliability, and performance.

In summary, the gap in IoT

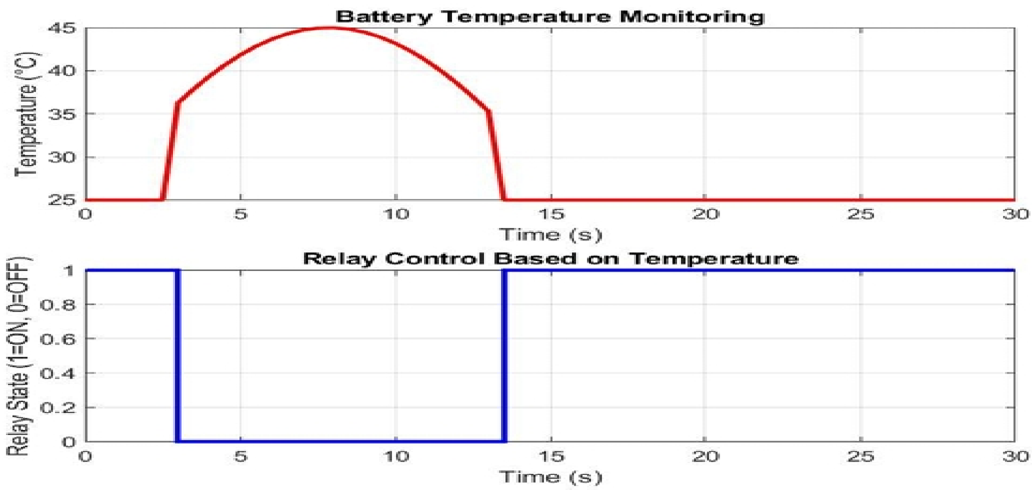

Fig. b) waveforms

Real- time IoT monitoring interface:

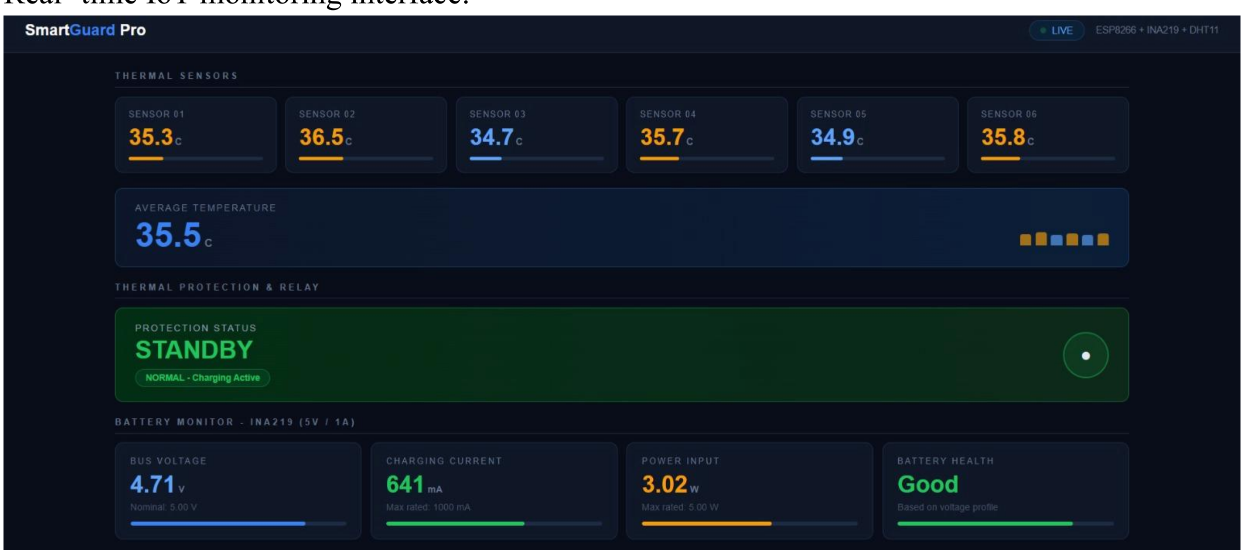

Fig. c) Normal condition

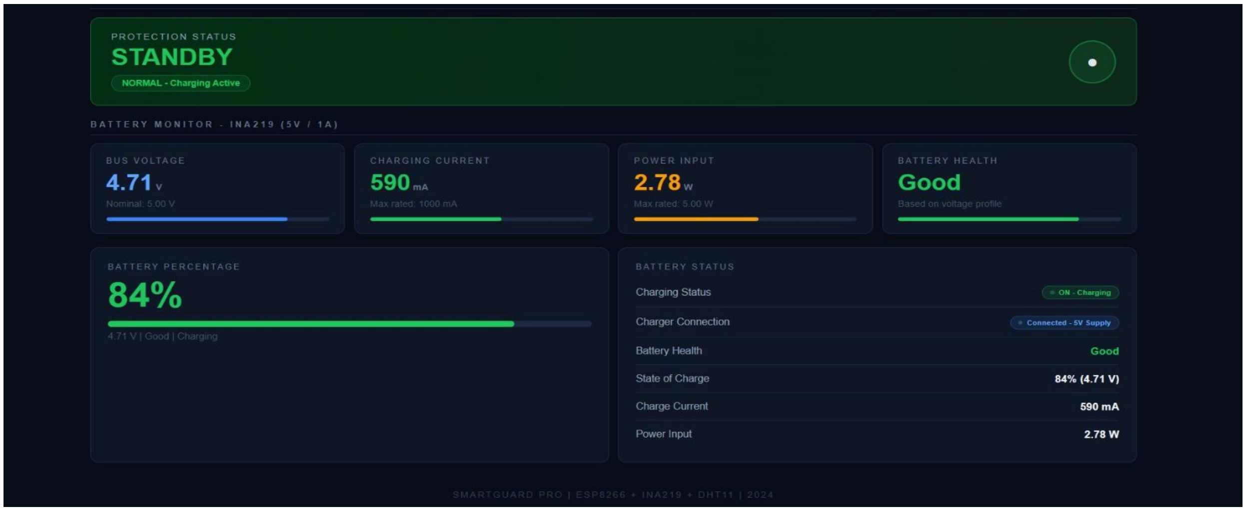

Fig. d) Normal condition

Fig. e) Abnormal condition

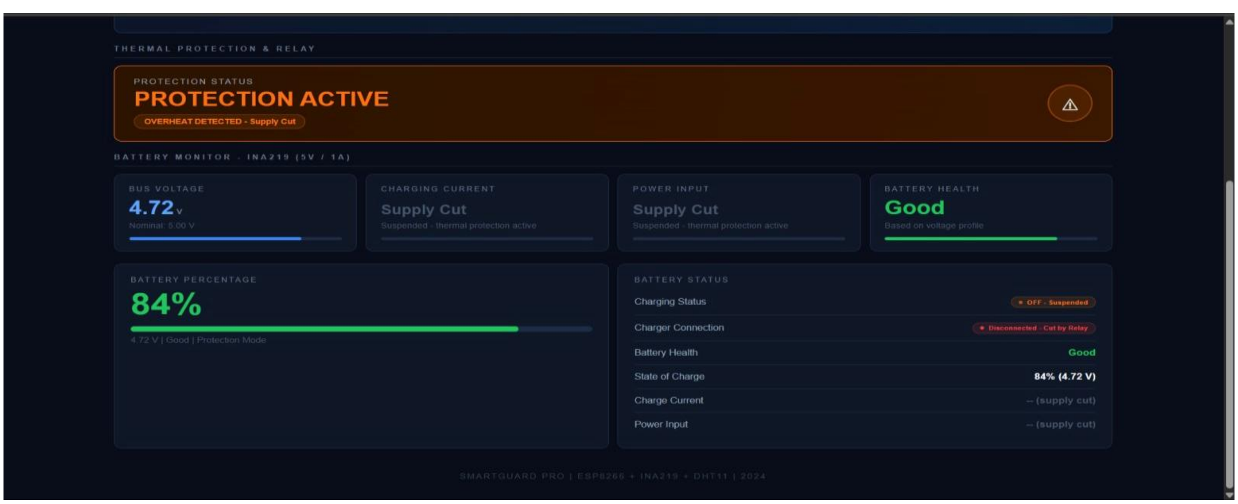

Fig. f) Abnormal condition

IX. CONCLUSION

The simulation results show that the proposed IoT-based battery charging safety system works effectively under different charging conditions. The system successfully monitored temperature, voltage, current values in real time and automatically disconnected the supply during unsafe conditions like overheating or overcurrent. The IoT feature also helped in remote monitored then alert generation, improving user awareness and charging safety.

The project proves that a low-cost microcontroller-based protection system can improve the safety, reliability, and efficiency of battery charging applications. However, before practical hardware implementation, factors such as sensor calibration, power stability, heat management, electrical noise, and reliable IoT connectivity should be carefully addressed. Overall, the system is a simple, effective, and scalable solution for safer battery charging and electronic device protection.

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