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IOT-Integrated Electric Vehicle Battery System Real-Time Monitoring, Safety Alerts and GPS Tracking

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Abstract: ***The integration of Internet of Things (IoT) technologies across various sectors has significantly improved the efficiency, safety, and sustainability of numerous systems. This proposed system presents an IoT-based solution that encompasses electric vehicle (EV) battery management, fire detection, and a GPS module, which effectively determines location in terms of latitude and longitude. The EV battery management system is designed to ensure the safe and efficient operation of electric vehicles by continuously monitoring voltage, temperature, and charging alerts. In contrast, the fire detection module employs smoke and temperature sensors to identify potential hazards in real-time. Moreover, a smart charging feature optimizes the charging process according to the battery's status and environmental conditions, which ultimately reduces time consumption. Additionally, the GPS module identifies the nearest charging station, thereby saving valuable time for users. The system utilizes the Node MCU ESP8266, a wireless module that provides alerts via mobile notifications when the battery percentage reaches critical levels of 30%, 70%, and 90%.***

Keywords: IOT, EV Battery Management, Fire Detection, GPS Tracking, Arduino UNO,

I. INTRODUCTION

The emergence of electric vehicles (EVs) signifies a notable advancement in our journey towards a greener and more sustainable future. Nonetheless, challenges related to battery performance, safety, and charging optimization persist and remain critical. Issues such as overcharging, overheating, and inefficient energy management can diminish battery lifespan and present significant safety threats, including fire hazards. This project introduces an innovative IoT-driven solution designed to tackle these pressing concerns. By merging real-time monitoring, fire protection mechanisms, and GPS tracking, the system aims to bolster both the efficiency and safety of EV batteries. Specifically, the Battery Health Monitoring feature meticulously tracks charging levels, voltage, and temperature in real-time, ensuring optimal performance and safety measures are upheld.



A smart smoke and temperature sensor effectively identifies potential fire hazards, promptly activating buzzer alerts and mobile notifications. This advanced system not only sends notifications when battery charging levels are either too low or excessively high but also automatically ceases charging upon reaching full capacity. Additionally, the integrated GPS module accurately determines the nearest charging station's location using latitude and longitude, ultimately saving valuable time.

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II. LITERATURE REVIEW

Several studies have explored IoT-based battery management and fire safety in EVs: Kumar et al. (2021) developed an IoT-driven EV monitoring system that improved charging efficiency and safety through real-time tracking[1].Sharma et al. (2022) introduced a fire hazard detection system using smoke sensors and automated emergency alerts[2].Gupta et al. (2023) proposed an automated charging cut-off mechanism, reducing overcharging risks and enhancing battery longevity[3].Jain et al. (2023) implemented GPS-based EV tracking, allowing users to monitor their vehicles in real time for better security[4].Singh et al. (2023) focused on cloud-based IoT monitoring, enabling remote battery health analysis and predictive maintenance[5]. H. Rahimi-Eichi, U. Ojha, F. Baronti, and M. Chow, "Battery Management System: An Overview of Its Application in the Smart Grid and Electric Vehicles," IEEE Industrial Electronics Magazine, vol. 7, no. 2, pp. 4-16,et al (2013)[6]. M. A. Hannan, M. M. Hoque, S. E. H. Tajuddin, and A. Ayob, "Lithium-Ion Battery Charge Applications," Renewable and Sustainable Energy Reviews, vol. 75, pp. 1363-1385, el at (2017) [7].G Vimalarani, BC Kavitha, Shaik Nihal, and K Rakesh. An iot-based power management system for ev chargers. In 2023 2nd International Conference on Edge Computing and Applications (ICECAA), pages 1329 1335. IEEE, 2023.

III. PROPOSED SYSTEM

The Intelligent EV Battery Management System uses sensors, IoT connectivity, and automation to enhance safety, performance, and efficiency. System Overview The system consists of several key components:



Fig 1: Proposed System

A. *System Components and its Functions*

1) *Arduino UNO:* It plays a vital role in collecting and processing dynamic data from sensors namely heart rate and temperature sensors. It reads analog signals from the sensors and converts into digital values. Then this processed data transmitted to ESP8266 Node MCU. It enhances the accessibility to detect location.



Fig- 2: Arduino UNO

2) *Node MCU ESP8266:* It serves as a communication channel between the Arduino Uno and Things speak cloud server, enables the real-time data transmission for monitoring. It transmits the data to cloud platform, where it can be stored, analyzed, and accessed through web applications. Its seamless connection to IoT makes a wireless module that provides alerts via mobile notifications when the battery percentage reaches critical levels of 30%, 70%, and 90%.



Fig-3: Node MCU ESP8266

3) *DHT 11 Sensor:* The DHT11 sensor plays a crucial role in monitoring environmental conditions by measuring the body temperature and humidity.It collects the vehicle temperature and humidity from through sensor and sends it to the Arduino UNO.



Fig-4: DHT 11 Sensor

4) *ACS 712 Sensor:* The load current is 10A hence current sensor having current rating greater than twice the rated current is desired. ACS 712 hall effect current sensor is s elected...



Fig-5: Voltage Sensor ACS712

5) *16x2 LCD display:* This Display serves as a local monitoring interface, it shows immediate readings like as voltage and current ,vehicle temperature and humidity. It allows users to check the temperature status without requiring of an external device. The Arduino UNO update the reading values based on the surrounding by the electric vehicle and DHT11sensors.



Fig - 6 :16x2 LCD Display

6) *Piezoelectric Buzzer:* It provides immediate audio alerts to the users when Upon temperature sensor over heated, the smoke sensor automatically activates, detecting smoke.



Fig-7: Piezoelectric Buzzer

7) *Power Supply:* A reliable power source crucial for the system's continuous functionality for consistent monitoring. The Arduino UNO and ESP8266 Node MCU typically run on 5V and 3.3V, respectively It consists step down transformer to provide stable power to system.

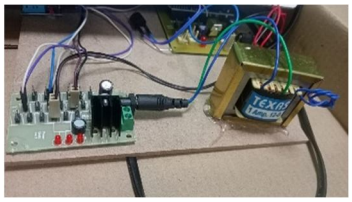


Fig-8: Power Supply

8) *GPS Tracer:* The system provides real-time vehicle location monitoring, improving security and the system provides real-time vehicle tracking, ensuring security and theft prevention.



Fig-9: GPS tracer module.

9) *MQ-2:* A smoke detector is an electronic fire-protection device that automatically senses the presence of smoke, as a key indication of fire, and sounds a warning to building occupants. A smoke sensor detects overheating or fire risks, triggering a buzzer and sending emergency alerts to the user's mobile device. Detects fire risks and sends alerts.

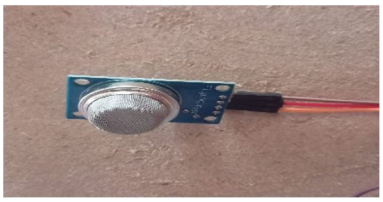


Fig – 10: Smoke sensor

IV. METHODOLOGY

This System follows an approach to collect, process, transmit, and analyze data in instantaneous. This System incorporates various sensors like pulse rate senor SR011 and DHT11 sensors, Arduino UNO, a cloud platform, ESP8266 Node MCU and alert mechanisms. The main purpose of this system is to predict and detect the fire hazard's, battery management and nearest charge station.

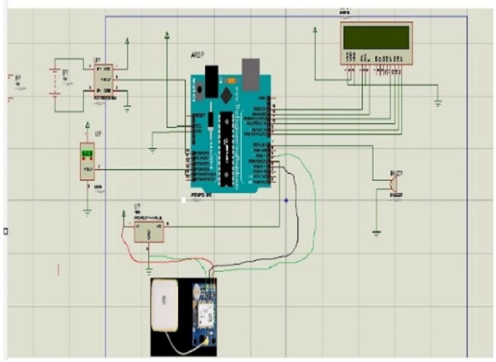


Fig11:-Schematic Diagram

1) 230V supply is provided to the step-down transformer which steps down the voltage up-to 12V.

2) Voltage regulator regulates the voltage up-to 5Volt as the Arduino UNO works on 5V supply.The Arduino UNO is connected with devices such as ESP8266 Wi-Fi Module, buzzer, 2x16 LCD Display, temperature sensor, fan, relays R1andR2 (which are connected for the supply of battery voltage) current sensor and the voltage sensor. When the supply is provided to the Arduino UNO, the relays then Switched ON and the battery gets charged, if any abnormal condition occurs the connected sensors will provide a signal to the Arduino UNO and automatic cut-off will be generated and charging will be switched off.

3) If the connected li-ion battery gets heated similar steps will be followed and signal will be sent via temperature sensor to the Arduino UNO and another signal is provided to the fan which is used to cool down the battery system.

4) The reading of the current and voltage is provided by the current sensor and voltage sensor which is first sent to the Arduino UNO and displayed on the LCD display for monitoring, one signal is also provided to the Wi-fi module which provides the reading over the Android or IOS based smart phone for 24x7 reading whenever it is needed it.

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A. System Overview

The system consists of several key components

1) Battery Monitoring: The ESP8266 Wi-Fi module and Arduino UNO continuously track battery levels, voltage, and temperature.

2) Fire Protection: A smoke sensor detects overheating or fire risks, triggering a buzzer and sending emergency alerts to the user's mobile device.

3) Node MCU (ESP8266 Wi-Fi): the node mcu is used to alerts through the mobile such as battery percentage reached 30%&70% and 90% eventually time will be save.

4) GPS Tracking: The GPS module identifies the location in terms of latitude and longitude.

V. RESULTS

The IoT-powered battery management system demonstrated efficient real-time monitoring, safety features, and energy optimization.

Fire Detection Speed:

1) The temperature and smoke sensor detected hazards in under 5 seconds and display temperature(30*c) value, how much humidity in the surrounding knowing by the see on lcd screen.



Fig12:- Temperature and Humidity value displayed on LCD.

2) The LCD display provides a measurement of the current, expressed in amperes, and the voltage, expressed in volts, that is circulating within the circuit, specifically in the context of the electronic vehicle.

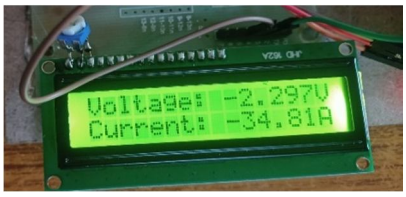


Fig13:- current and voltage value displayed on LCD

3) The system delivered highly accurate updates on vehicle locations, enhancing security while clearly identifying each position in terms of latitude and longitude coordinates.

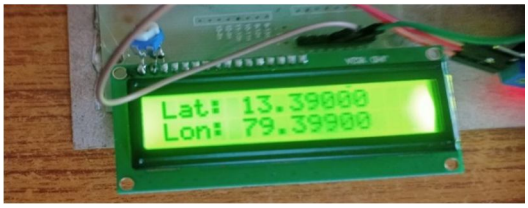


Fig 14:- longitude and latitude value displayed on LCD

4) Upon temperature sensor over heated, the smoke sensor automatically activities, detecting smoke and sending the fire alerts via buzzer.



Fig15: -Detecting the flame displayed on LCD

	created_at	entry_id	field1	field2	latitude	longitude	elevation	status
2	2025-02-221	1	48.5v	35°c	37.7749	-122.419	15m	Normal
3	2025-02-221	2	50.2v	40°c	38	-122.419	18m	Overheated
4	2025-02-221	3	47.0v	30°c	37.7749	-122.42	12m	stable
5	2025-02-221	4	51.0v	45°c	37.7755	-122.419	20m	critical(Fire Alert

Fig 16:- Data Provided by Thing speak

Key Benefits

✔ Prevents Battery Overcharging & Damage

✔ Enhances Fire Safety through Real-Time Alerts

✔ Provides Smart Charging Analytics & Remote Monitoring

✔ Ensures Vehicle Security with GPS Tracking

VI. CONCLUSION

This review paper briefly explains the study of Battery Management System of an Electric Vehicle by considering several parameters including battery voltage, temperature, current, humidity, smoke levels (fire detection), and GPS coordinates for real-time monitoring and safety optimization. which are important for monitoring and taken into consideration to avoid explosion of Li-Ion Battery Cells. Several papers are reviewed to understand the behaviour of Li-Ion battery, technology used for gathering information through IoT, etc. Moreover, this paper has investigated about IoT technology that can be used for monitoring purpose of age. The information or data we receive through different sensors is used for monitoring purpose and protecting our battery from being destroyed. It also helps to increase the life of the battery and makes it reliable to use for the Electric Vehicle.

VII. FUTURE SCOPE

AI-Driven Predictive Maintenance – Using machine learning to forecast battery failures. Cloud-Based Analytics Dashboard – Advanced IoT-powered insights for EV owners. Solar-Powered Charging – Integration with renewable energy for sustainable EV charging. By leveraging IoT and automation, this system improves the safety, lifespan, and usability of EV batteries, making it a viable solution for modern electric vehicle

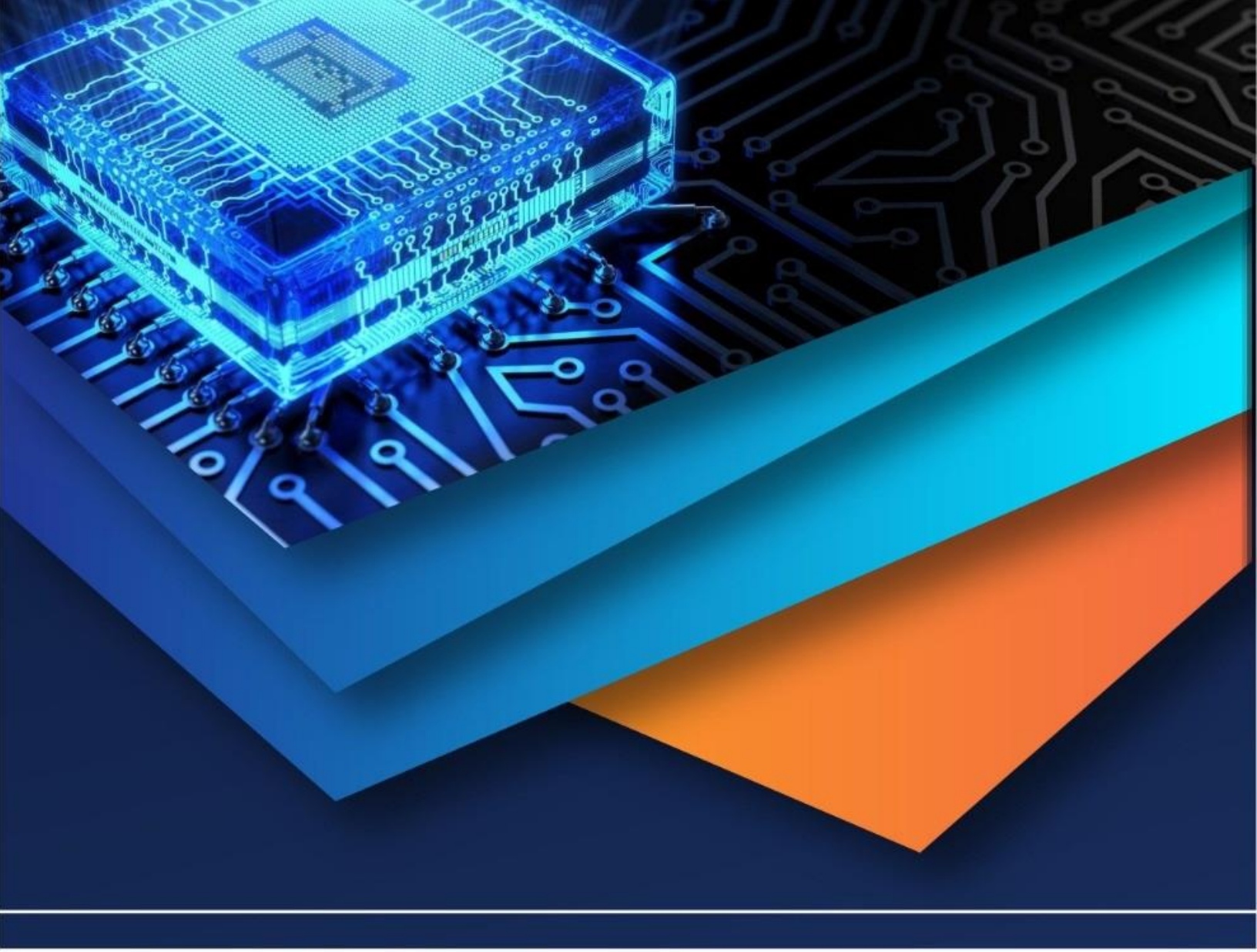
VIII. ACKNOWLEDGMENT

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