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Advanced IoT-Based EV Battery Management with Real-Time Charge Monitoring and Fire Protection

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ABSTRACT

The Battery Management System (BMS) is a critical component in Electric Vehicles (EVs) that ensures the safe and optimal performance of the battery pack. This abstract outlines the importance of a BMS and burning prevention in EVs. The BMS monitors the state of charge, temperature, and voltage of each battery cell and balances the cells to avoid overcharging or discharging, which can lead to reduced battery life or even fire incidents.The burning prevention system involves the use of sensors, software, and other safety measures to detect and mitigate potential risks of battery fires in EVs. With the rapid growth in the EV market, BMS and burning prevention systems are essential for ensuring the safety and reliability of EVs.

Our system monitors and stores parameters that provide an indication of the lead acid battery's state of charge, voltage, current, and the remaining charge capacity in a real- time scenario. Wireless local area network is used as the backbone network. The information collect from all the associated battery clients in the system is analyzed. The malfunction of the battery is monitored continuously and sudden charge & discharge voltage of battery bank and battery conditions are viewed with help of IoT module. When a temperature of the battery reaches the threshold, the battery output is suddenly cut off and a buzzer sounds an alert.

INTRODUCTION

The industrial process expansion has become very complex in the electronics system. In such developing industrial field fault detection and fault isolation is very important. This proposed work reduces the system in identifying the fault in the EV. The vulnerable part in the EV is the battery. Battery performance is influenced by factors such as depth of discharge (DoD), temperature and charging time. This paper attempts to provide the current level and voltage level using Internet of Things. By depending on the output of the battery fault can be analyzed.

The battery is a device that converts the chemical energy into electrical energy through electrochemical reaction. Lead Acid battery is the most commonly used battery in UPS. To know the present status of the battery some important parameters are to be measured in regular interval. The important parameters are terminal voltage, load current, discharge current, room temperature of each battery used in the battery. The UPS that are used in the industries require electric power for smooth operation. The systems are equipped with lead acid batteries as an alternate source of electric power.

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Battery management system (BMS) forms a crucial system component in various applications like electric vehicles (EV), hybrid electric vehicles (HEV), uninterrupted power supplies (UPS), telecommunications and so on. The accuracy of these systemshas always been a point of discussion as they generally give an error of maximum 10% considering all the parameters together. Batteries are the heart of the automationsystem, and its applications are more in all the fields, where the electrical supply requires. The periodical monitoring/observations are required for battery source to provide continuous power to the load without any interruption.

LITERATURESURVE

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MAJOR FINDINGS FROM LITERATURE SURVEY

Atzori et; al (2017) proposes Understanding the Internet of Things: Definition, potentials, and societal role of a fast-evolving paradigm. Ad Hoc Netw. 2017, 56, 122–140.The Internet of Things (IoT) has been inscription in this review paper. Internet of Things is a keyword to cover various challenges related to internet and the web to the real physical world. We know that, today internet has already taken an important part of everyday life and it has also dramatically changed the lives of human being. The most important factor of this invention is, integration or combination of several technologies with the communication system solutions. The most applicable factors ofIoT are the identification and tracking various factors for smart objects. The universal sensing networks is enabled by Wireless Sensing Networks (WSN) and these technologies cuts across many areas of modern day living. The escalation of these devices in a communicating and actuating network will create the Internet of Things (IoT). Here the sensors and actuators combine easily with the environment around us and the information is shared across various platforms in order to develop a common operating picture (COP). Internet of Things predicts the future that, the advance digitalworld and the physical world will get linked by means of proper information and wireless communication system technologies. In this survey paper they have mentioned the visions, concepts, technologies, various challenges, some innovation directions, and various applications of Internet of Things (IoT).

C. Wu et; al (2015) proposes Research on overcharge and over discharge effect on Lithium-ion batteries", Proc. IEEE Veh. Power Propul. Conf., pp. 1-6, 2015. The purpose of this study is to diagnose and analyses the overcharge and over discharge fault of lithium-ion battery. Through the dynamic simulation model, the phenomenon of overcharge and over discharge fault for automotive lithium-ion battery (LIB) was discussed, and the fault diagnosis effect was summarized. The results of this study show that the fault diagnosis analysis of LIB can achieve good results. It is of certain

application value for diagnosis of LIB with different parameters. Therefore, it's concluded that the overcharge and over discharge faults of automotive LIB are likely to jeopardize the using effect of the batteries, which should attract more attention of relevant automobile manufacturers.

López-Benítez et; al (2017) proposes Prototype for Multidisciplinary Research in the context of the Internet of Things. J. Netw.

Comput. Appl. 2017, 78, 146–161. This work proposes a novel mathematical approach to accurately model data traffic for the Internet of Things (IoT). Most of the conventional results on statistical data traffic models for IoT are based on the underlying assumption that the data generation follows standard Poisson or Exponential distribution which lacks experimental validation. However, in some of the use case applications a single statistical distribution is not adequate to provide the best fit for the inter-arrival time of the data packets generation. Based on the real data collected for over 10 weeks using their customized experimental IoT prototype for smart home application, in this paper they have established this very fact, citing barometric air pressure as an example.

This paper presents a remote online monitoring system for the operation of lead- acid battery group in telecommunication base stations. Combining the General Packet Radio Service (GPRS) communications and Internet connections, the system realizesdata transmission between remote acquisition modules and data services center. The collected data of battery parameters in the center are analyzed and processed, and then it can be monitored by using any standard browser distributed worldwide if access permission is given. Both battery users and battery manufactures can use the system for the battery power management, maintenance and troubleshooting.

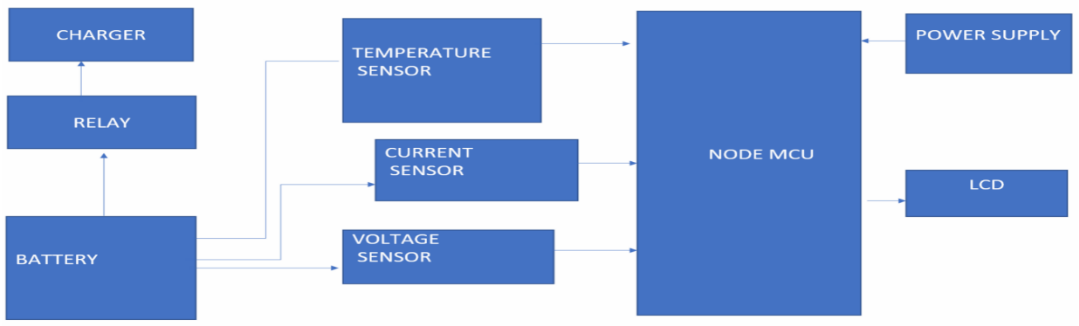
O. A. Mohamad et; al (2016) proposes Design and implementation of real time tracking system based on arduino intel galileo", Electronics Computers and Artificial Intelligence (ECAI) 2016 8th International Conference on with the rapid increase in advancement in the world of technology, it has become highly important to the people to have the flexibility to monitor and control their physical property as well as personal data. Although physical transportation systems have made it easier for people to

travel, it has also become a hazard in several ways. Therefore, a real-time tracking device has been designed in this project to cater to the issues of monitoring of vehicles. In this paper, we developed a system using Arduino Uno R3, Global System for Mobile (GSM) device and Global Positioning System (GPS) to track the exact and accurate position of the vehicle at a location. Arduino IDE software is utilized to code the ArduinoUno R3 and its microcontroller.

The system is also equipped with display facilities to show the information to the user. The latitude and longitude of the vehicle's location are displayed on Liquid Crystal Display (LCD). Furthermore, two software is utilized to display the data. ThingSpeak was used to display the trend of the vehicle's motion by using charts of latitude and longitude, and Freeboard is utilized to display the same information in the form of a map.

This map could easily be read by the user to pinpoint the exact location of the vehicle at any given time. It will be highly useful to monitor the exact locations of the delivery vehicle used by food-related businesses. Finally, by having latitude and longitude, users can successfully track their vehicle location on electronic maps using internet. Thus, the entire system has been tested thoroughly in real time and it is said to function successfully in helping users to locate their vehiclesin the event of a theft.

BLOCK DIAGRAM OF BATTERY MONITORING SYSTEM



AIM OF THE PROJECT

The aim of battery management and burning prevention of electric vehicles is to ensure the safe and reliable operation of the vehicle's battery system, while minimizing the risk of fire or other hazards.

Battery management systems (BMS) are responsible for monitoring and controlling the state of charge, temperature, and other key parameters of the battery to ensure that it operates within safe limits. The BMS also provides early warning of potential faults or issues with the battery system, allowing for timely maintenance and repairs.

In addition to BMS, other safety features are incorporated into electric vehicles to prevent battery fires and other hazards. These can include thermal management systems to regulate the temperature of the battery pack, as well as electrical safety features such as fuses and circuit breakers to prevent electrical faults and short circuits.

The aim of battery management and burning prevention is to ensure that electric vehicles are as safe and reliable as possible, while also promoting the wider adoption of electric vehicles as a sustainable and environmentally friendly transportation option. By providing confidence in the safety and reliability of electric vehicles, battery management and burning prevention can help accelerate the transition to a low- carbon transportation system.

SCOPE OF THE PROJECT

The development of efficient and reliable battery management systems and burning prevention techniques is crucial for the widespread deployment of electric vehicles. The current state of research indicates that multi-objective optimization methods, machine learning-based methods, and advanced sensor technologies, along with flame retardant coatings, ventilation systems, and thermal management techniques, are promising areas for further studies. By integrating these innovations,

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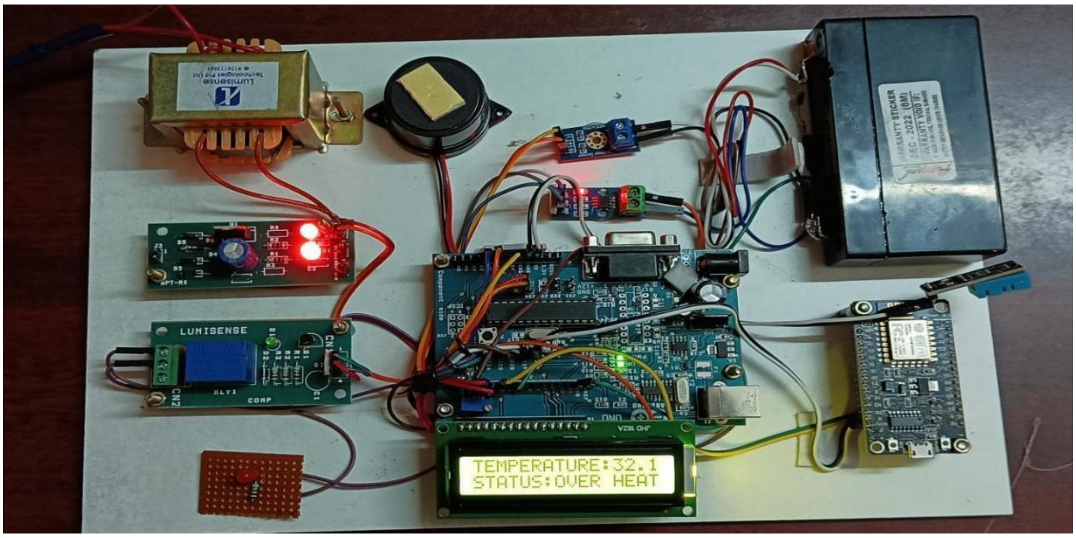
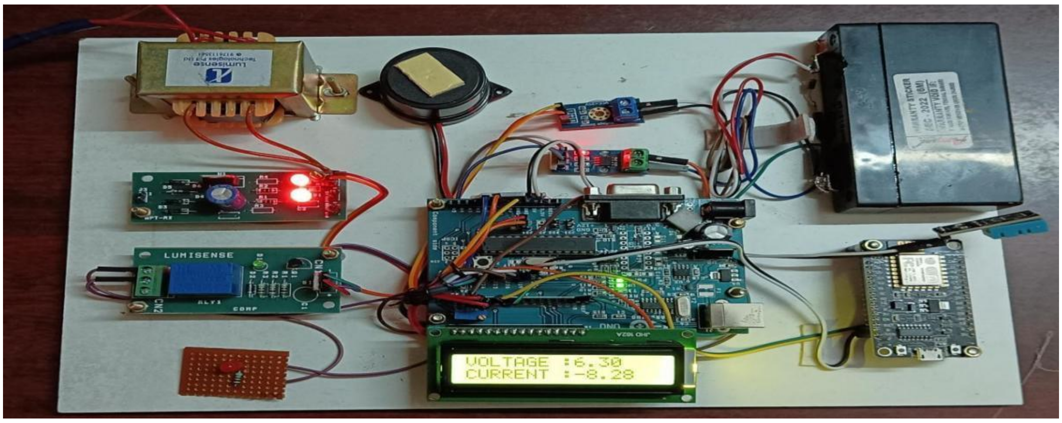
RESULTS AND DISCUSSIONS

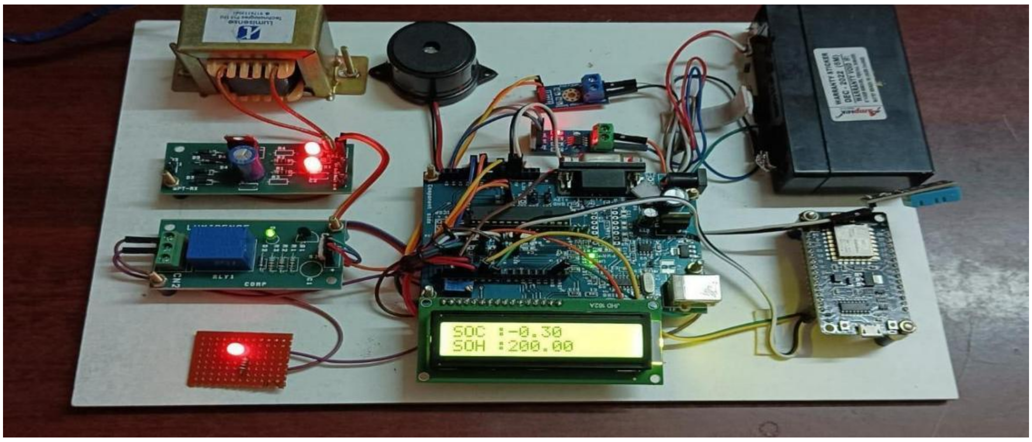


HARDWARE OUTPUT

When high temperature is detected as shown in figure 5.1, the Microcontroller unitin the NodeMCU sends a high signal to a relay module which turns off the power supply which is indicated by turning off of LED.

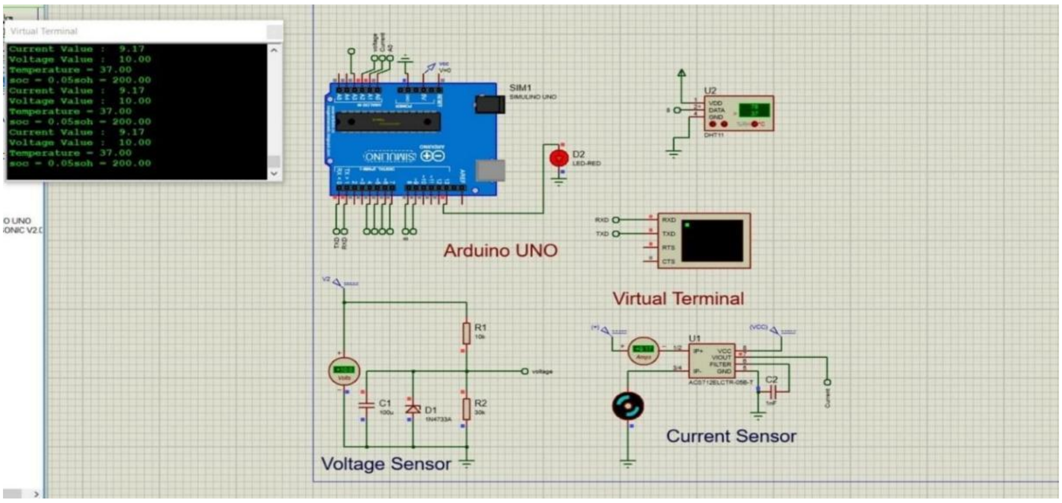


The current and voltage sensor values are detected from the respected sensors andare displayed in the LCD screen as shown in figure



The SOC and SOH values are calculated from the formulae and are displayed inthe LCD display as shown in figure

SIMULATION OUTPUT



IOT DATA

The NodeMCU plays a vital role in this system, which senses the data from sensors and process the data. The Wi-Fi unit in the NodeMCU is used to send the data to the cloud, this data can be monitored continuously from anywhere in the world(where there is an active internet connection) and also whenever an excess current is detected at the supply the buzzer is activated to alert the administrator.

The graph referring to is a visual representation of data collected from an Internet of Things (IoT) based battery management system (BMS) for an electric vehicle (EV).

The BMS is a system that monitors and manages the battery pack of the EV tooptimize its performance, efficiency, and lifespan.

The x-axis of the graph represents time, while the y-axis represents various parameters related to the battery performance.

An IoT-enabled battery management system can provide valuable insights into thecurrent status of electric vehicle batteries, prevent potential safety hazards, and ensure the optimal performance of the battery over its

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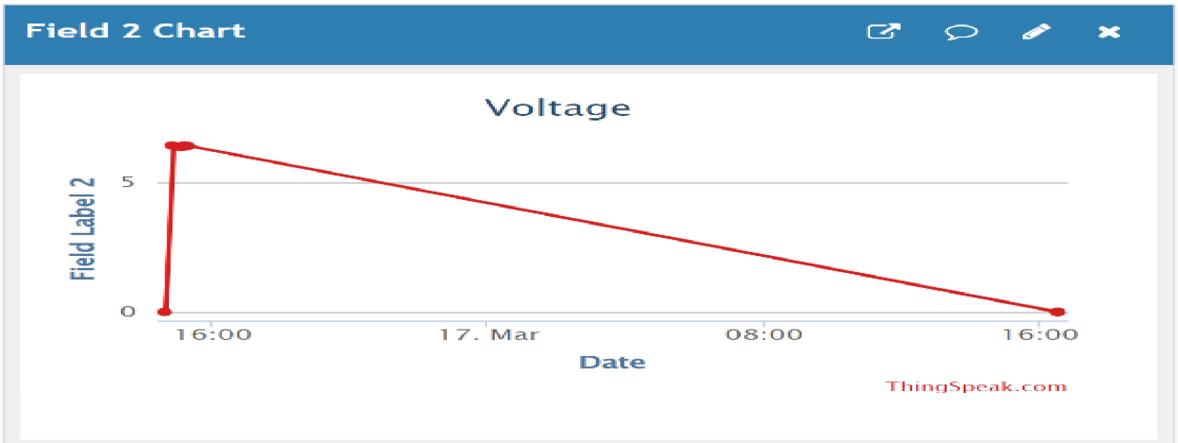
lifespan. The Current graph is a critical component of this system, providing real-time data on the current status of the battery to ensure the electric vehicle operates safely and efficiently. Figure 5.5 depicts the current graph using IOT.



Photocopy of voltage graph using IO

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When the parameter is voltage, the x-axis of the graph represents time, while the y-axis represents the voltage of the battery pack, typically expressed in volts (V). Thegraph may display the historical voltage values of the battery over time, showing howthe battery's voltage changes during different operating conditions.

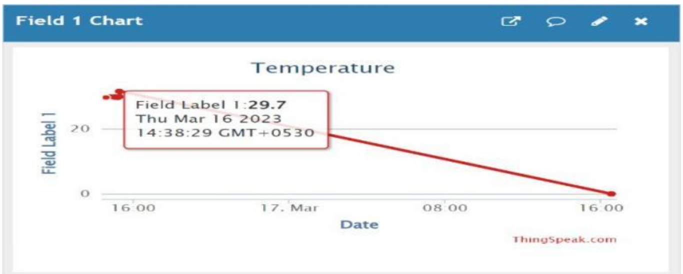
The graph shows trends or patterns in the voltage values, providing insights into the battery's electrical behavior. For example:

Charging and Discharging Events: The graph may show the voltage values during charging events, indicating how the battery voltage increases over time as it is charged. It may also show the voltage values during discharging events, representinghow the battery voltage decreases during EV operation as energy is drawn from the battery.

Voltage Profiles: The graph may show the voltage profiles of the battery during different stages of operation, such as during startup, normal operation, and shutdown.This can help identify any abnormal voltage behaviors, such as voltage spikes or drops, which may indicate issues with the battery's performance or health.

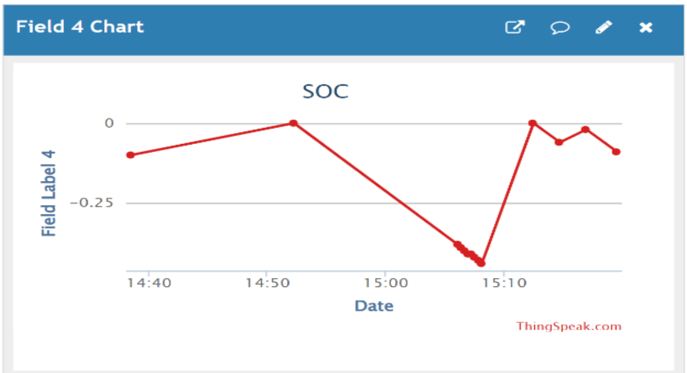
Voltage Range: The graph may show the voltage range of the battery, indicating the upper and lower limits of the acceptable voltage levels. Monitoring the battery voltage

within the acceptable range is crucial to ensure safe and reliable operation of the EV,as operating outside of this range may lead to overcharging, over-discharging, or otherundesirable effects on the battery's performance and lifespan.



Photocopy of temperature graph using IOT

When the parameter is battery temperature, the graph would display the current temperature of the battery pack at different time points. It would show how the temperature changes over time, indicating the current temperature status of the battery as shown in the figure 5.7 and when the overheating occurs an alert will be triggered based on the graph values



Similarly, when the parameter is SOC, the graph will show the percentage of chargeremaining in the battery pack at different time points. It would display the current SOCvalue at a specific time as shown in figure 5.8, and the graph would update in real- time as the SOC changes with the battery charging or discharging.

The graph may show trends or patterns in the SOC values, providing insights into the battery's charging and discharging behavior. For example:

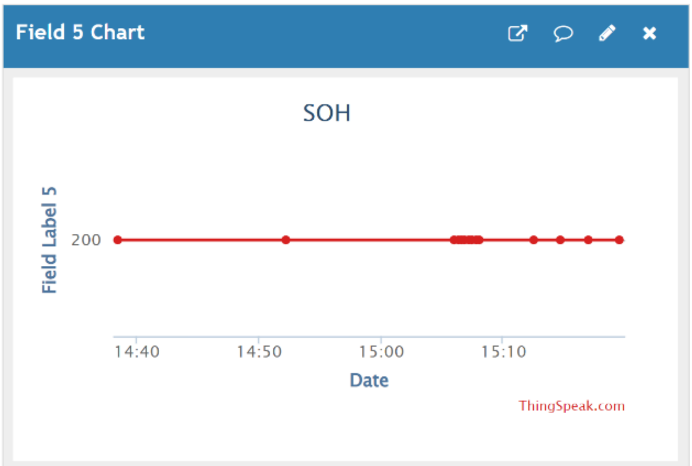
Charging and Discharging Events: The graph may show the SOC values during charging events, indicating how much the battery is being charged and how the SOC increases over time. It may also show the SOC values during discharging events, representing how much the battery is being discharged and how the SOC decreases during EV operation.

SOC Fluctuations: The graph shows fluctuations in the SOC values during driving, reflecting changes in driving conditions, regenerative braking, and other factors that affect the battery's charge level. These fluctuations can help identify the energy usagepattern of the EV and optimize driving behavior or charging strategies accordingly.

Charging and Discharging Efficiency: The graph shows the efficiency of charging anddischarging processes by comparing the amount of energy input during charging with the amount of energy output during discharging. This can provide insights into the overall efficiency of the charging and discharging processes and help optimize charging strategies to improve the battery's performance and extend its lifespan.

The graph can provide real-time information on the current SOC of the battery, enabling EV operators to make informed decisions about when and how to charge the battery, plan driving routes, and manage energy consumption. It can also help detect any anomalies or issues with the battery's SOC, such as overcharging or deep discharging, triggering alerts or alarms in the IoT-based BMS for prompt action. By monitoring and managing the SOC of the battery using an IoT-based BMS, it is

possible to optimize the EV's energy usage, extend the battery's lifespan, and ensure reliable and efficient operation.



: Photocopy of SOH graph using IOT

When the parameter being measured is SOH, the x-axis of the graph represents time, while the y-axis represents the SOH of the battery pack, typically expressed as a percentage. The graph as shown in figure 5.9

may display the historical SOH valuesof the battery over time, showing how the battery's health changes and degrades as itundergoes usage cycles and aging.

The graph shows trends or patterns in the SOH values, providing insights into the long-term performance of the battery. For example:

Initial SOH: The graph may show the initial SOH of the battery when it is first put into service. This provides a baseline reference for the battery's health at the beginning of its operational life.

Aging Trend: Over time, the graph may show a declining trend in the SOH values, indicating that the battery's health is gradually degrading due to usage, temperature, and other factors.

This trend can help identify the rate of battery degradation and estimate its remaining useful life.

Anomalies: The graph may show any significant changes or anomalies in the SOH values, such as sudden drops or spikes, which may indicate unusual events or conditions that have affected the battery's health. These anomalies can trigger alerts or alarms in the IoT-based BMS, enabling prompt action to address potential issues.

The graph can provide valuable information for EV operators and maintenance personnel to assess the health and performance of the battery pack over time. This data can be used to optimize charging strategies, schedule maintenance activities, and make informed decisions about battery replacement or refurbishment. By monitoring and managing the SOH of the battery in real-time using an IoT-based BMS,it is possible to maximize the lifespan, efficiency, and safety of the EV battery, ensuring reliable and sustainable operation.

SUMMARY AND CONCLUSIONS

Battery management system (BMS) is an essential component in electric vehicles(EVs) to monitor, control and maintain the state of the battery. It is responsible for predicting range, preventing overcharging, detecting faults, balancing cell voltages, and preserving the battery's life span. The BMS also ensures that the battery is used in a safe and optimal manner to avoid any accidents or hazards.

In addition to the BMS, burning prevention is a crucial feature in EVs to prevent fire incidents caused by battery malfunction. The burning prevention system monitors the temperature and voltage of the battery and detects any abnormalities such as overcharging or overheating. Once any anomaly is detected, the system takes immediate action to prevent a potential fire breakout by disconnecting the battery or signaling the driver to park the vehicle in a safe location.

Together, the BMS and burning prevention system ensure that EVs are safe, efficient, and sustainable transportation options for the present and future generations.

FUTURE SCOPE

- Improved battery management algorithms: With the advent of artificial intelligence and machine learning technologies, there is a lot of scope for developing better algorithms to manage the life of electric vehicle batteries. These algorithms can predict battery aging, optimize charging cycles, and improve energy efficiency.

Advanced energy storage technologies: There is a growing need for energy storage technologies that can provide higher energy density and longer cycle life for electric vehicle batteries. Research is underway

- Battery recycling: Proper recycling of electric vehicle batteries is crucial to prevent environmental damage. Several research projects are focused on developing more efficient and sustainable battery recycling methods.
- Enhanced thermal management systems: Thermal management is a critical issue for electric vehicle batteries as overheating can damage them. Advanced thermal management systems that can provide better cooling and heating for batteries can improve their performance and prolong their lifespan.
- Integration with smart grid technologies: As electric vehicle adoption increases, it becomes important to integrate EVs with smart grid technologies. Battery management systems can be used to monitor the energy consumption of EVs and optimize their charging cycles to minimize the impact on the grid.
- Improved safety features: Electric vehicles need to be equipped with advanced safety features to prevent battery fires and other accidents. Battery management systems can be enhanced to provide better monitoring of battery temperature, voltage, and current, to detect any potential hazards early and prevent accidents from occurring.

CONCLUSION

The fully electrically operated vehicles will come in future because of depleting fossil fuels and will definitely create an impact in everyone's life. At this time the battery management system will be major phenomena that every electric vehicle manufacturing company will be looking for. It is clear that an electric vehicle totally depends on the source of energy from a battery.

In this work, the idea of monitoring the performance of the vehicle using IoT techniques is proposed, so that the monitoring can be done directly. The system is capable to detect degraded battery performance and sends notification messages to the user for further action.

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