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TO ANALYSIS OF EV BATTERY MANAGEMENT SYSTEM WITH CHARGE MONITOR AND FIRE PROTECTION

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ABSTRACT - The adoption of electric vehicles is growing rapidly due to their environmental benefits and technological advancements. A key component of EVs is the Battery Management System, which ensures the safe, efficient, and reliable operation of the vehicle's battery pack. A basic introduction of EV BMS is presented in this paper, with an emphasis on fire safety and charge monitoring. The BMS's charge monitoring function makes sure the battery cells run within acceptable ranges for voltage, current, and temperature. This involves keeping an eye on individual cell states to prevent overcharging or deep discharge, which can lead to performance degradation or safety risks. On the other hand, fire protection mechanisms integrate advanced thermal management, fault detection, and emergency response protocols to mitigate fire hazards caused by thermal runaway, short circuits, or external damage.

Keywords:- Electric Vehicle, Battery Management System, Charge Monitoring, Fire Protection, Emergency Response Systems, Thermal Management, Fault Detection, Overcharging Prevention.

I. INTRODUCTION

An electric car EVs is a type of vehicle that uses one or more electric motors for propulsion. An EV uses a battery pack to store electrical energy to power an electric motor that moves the wheels, as opposed to an internal combustion engine that burns fuel. Compared EVs provide several advantages, including lower emissions, more silent operation.

Reliance on fossil fuels. Since electricity is frequently less expensive than gasoline and electric motors are more efficient than ICEs, they also typically have reduced operational expenses. Journal of Creative Research Thoughts The popularity of EVs is fast rising as the globe moves towards a cleaner, more sustainable future. Governments all around the world are granting incentives to stimulate the use of EVs, and numerous automakers are already selling a variety of EV models. In addition to its benefits, common EV problems include internal cell shorts that may result in thermal runaway.

An EV typically catches fire because of excessive heating. The electric vehicle's battery warms up, and when that heat interacts with petrol that has leaked, the battery simply catches fire.

A battery management is an electrical device that controls and keeps track of the operation of rechargeable batteries, such as those found in renewable energy sources and electric cars. The BMS normally consists of a number of parts such as sensors for measuring the temperature , voltage, and current of the battery as well as control circuits for controlling how the battery is charged and discharged in response to various conditions. Software algorithms that forecast the battery's remaining capacity and project its remaining life may also be present in the BMS.

On-going research aims to make BMS more efficient, cost-effective, and scalable to support the growing demand for EVs. In conclusion, the literature highlights the critical role of charge monitoring and fire protection in BMS design. Continuous advancements in these areas are vital for ensuring the safety and reliability of electric vehicles. Due to a discrepancy between the quantity of energy consumers use and the amount of energy generated by generation sources, the current electric grid is an inefficient system that wastes a considerable amount of the electricity it generates. In order to assure adequate power quality, power plants often produce more energy than is required. Many of these inefficiencies can be eliminated by making use of the energy storage that already exists inside the grid. To accurately monitor and regulate the storage system while using battery.The essay describes the Matthew T. Lawder; Bharatkumar Suthar; Paul W. C. Northrop; Sumitava De; C. Michael Hoff; Olivia,2008 Although the reliance of energy systems on battery storage systems is constantly growing, there are still a number of issues that need to be resolved. Current battery systems are rigid; only cells with the same electrical characteristics may be coupled; and cell flaws significantly shorten the lifespan of the entire battery or even trigger a system blackout.

Current Battery Management Systems (BMS) are able to enhance the maximum useful charging current as well as the useable battery capacity to some extent. Published in: 2014 M.Hesan in 16th European Conference on Power Electronics and Applications The integration of Artificial Intelligence (AI) and Internet of Things (IoT) technologies is transforming BMS design. AI-based systems can analyze vast amounts of data in real-time. Emergency response systems, such as automated shutdowns and fire suppression systems, have also been studied to enhance safety in the event of a critical fault. Recent studies have focused on integrating Artificial Intelligence and Internet of Things technologies into BMS for real-time data analysis and remote monitoring. These innovations allow for smarter and more adaptive systems, improving both safety and performance. Additionally, emerging battery technologies, such as solid-state batteries, are gaining attention for their inherent safety features, including greater resistance to thermal runaway.

II. LITERATURE REVIEW

Battery Management Systems are a critical component of electric vehicles , ensuring the safety, performance, and longevity of the battery pack. Early studies on primarily focused on monitoring basic parameters such as voltage and current at the battery pack level. As EV adoption increased, researchers identified the need for more sophisticated systems capable of monitoring individual cells and managing the dynamic nature of battery operations. These systems have become essential for maintaining the balance between energy efficiency and safety in EV applications.

Charge monitoring is one of the primary responsibilities of a BMS. It ensures that each battery cell operates within safe voltage and current limits to avoid overcharging or overdischarging, which can damage the cells or reduce their lifespan. Literature highlights the development of algorithms for accurate estimation of the State of Charge , such as Coulomb counting and model-based approaches. Furthermore, researchers have introduced cell balancing techniques, which equalize the charge levels across cells to prevent imbalances that can lead to inefficiencies or safety issues. Thermal runaway is a critical safety concern for lithium-ion batteries, where excessive heat triggers a chain reaction that can lead to fires. Studies have explored methods to address this, including advanced thermal management systems.

Cooling mechanisms like liquid cooling, air cooling, and phase-change materials have been investigated to dissipate heat effectively. Research also emphasizes the integration of temperature and gas sensors into the BMS to detect early signs of thermal instability and prevent catastrophic failures. Fault detection is another essential function of the BMS. Researchers have developed diagnostic tools and algorithms to identify potential issues such as short circuits, overloading, or mechanical damage. Modern BMS designs incorporate real-time monitoring and predictive analytics to anticipate and mitigate risks.

III. METHODOLOGY

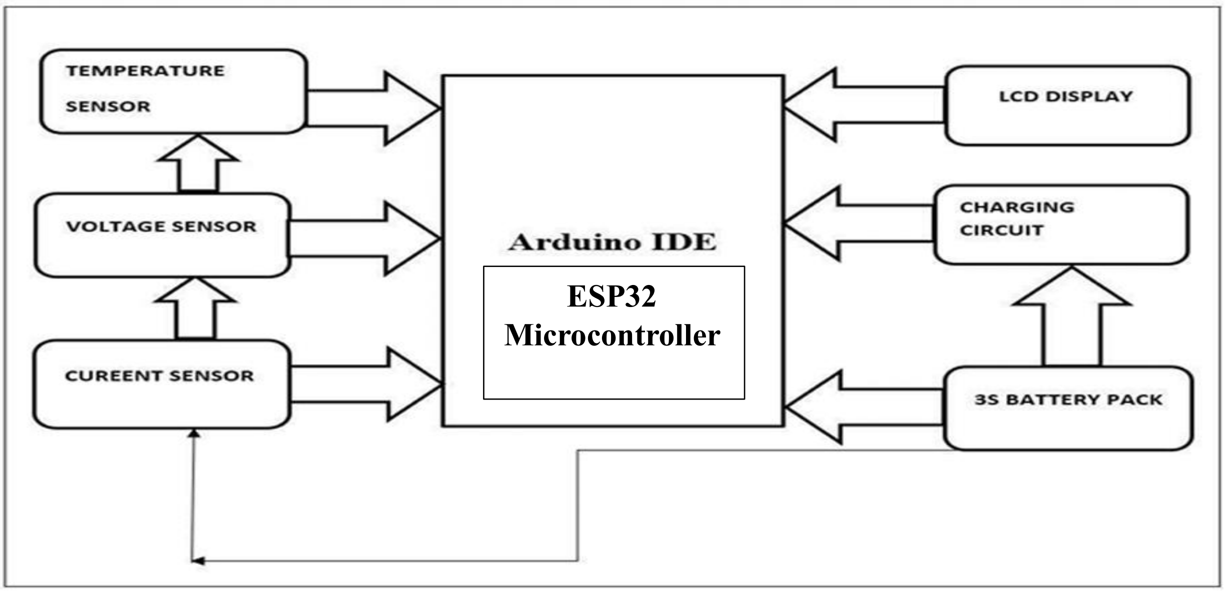

Fig.1-.Block Diagram

i. Power Supply System:-

A project like this is critical for ensuring that a 12V battery pack operates safely, efficiently, and with optimal lifespan, making it especially useful for EVs and other renewable energy applications.

Fig 2.- Battery pack 12v

ii. Relay Module:-

A relay is an electrically operated switch that allows a low-power signal to control a higher power circuit. It consists of an electromagnet, a set of contacts, and a spring. Relays are commonly used in automation, control systems, and safety applications to isolate different parts of a circuit and switch high-power devices using low-power control signals

Fig.3-.Realy

iii. LCD:-

An LCD (Liquid Crystal Display) is a flat-panel display technology that uses liquid crystals to modulate light and create images. It operates by applying electrical currents to liquid crystals, which alter their alignment and allow light to pass through or be blocked. LCDs are energy-efficient and thinner than traditional CRT displays.

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Fig.4-.LCD Display

iv. DC cooling Fan:-

A 12V DC fan is a type of fan that operates on a 12-volt direct current (DC) power supply. It is commonly used in cooling applications, such as in computers, automotive systems, and small appliances, due to its low power consumption, portability, and ability to run on battery-operated systems.

Fig,5-,Dc cooling fan

IV. SYSTEM MODEL

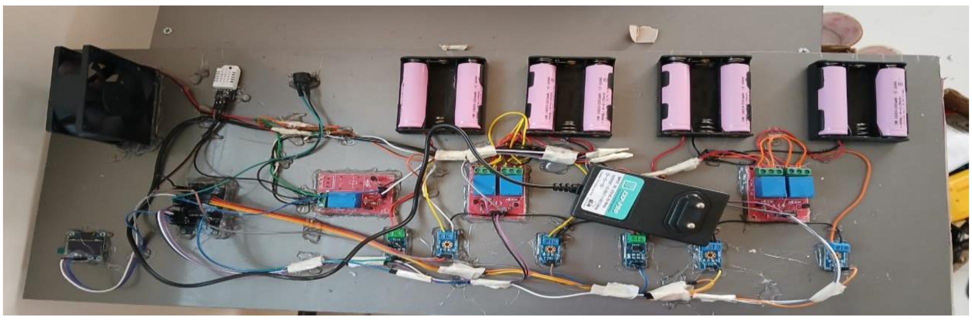

Fig. 6-. system model

V. CALCULATION AND RESULT

Cell type Li-ion

Cell capacity 2500 mAh (2.5 Ah)

Number of cells (series) 12

Number of cells (parallel) 3

Total capacity 2.5 Ah × 4 = 10 Ah

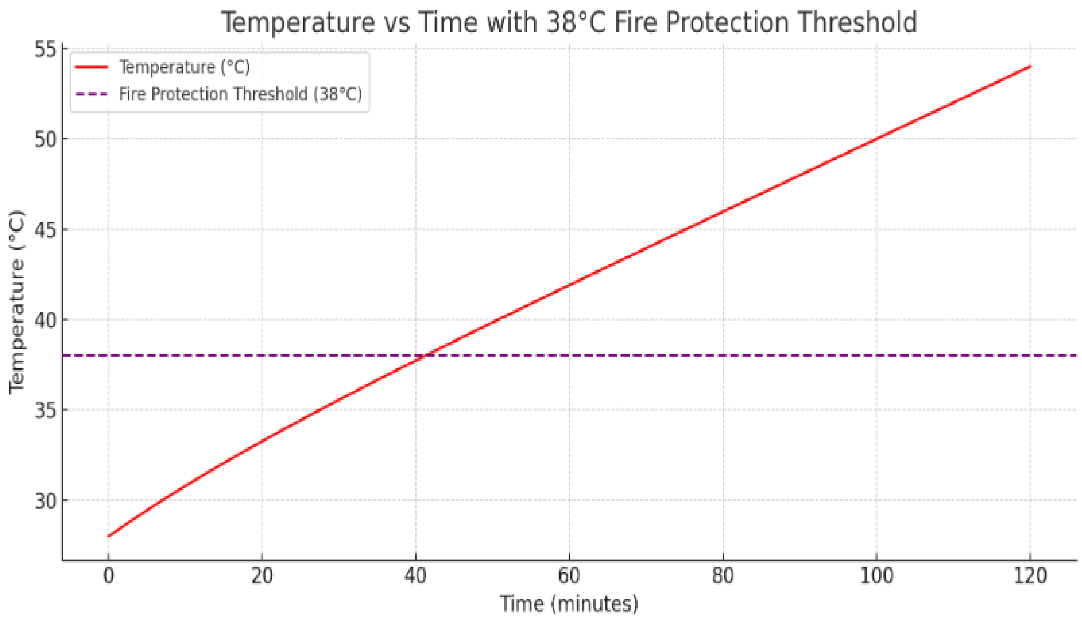

Fig.7-. output response

VI. CONCLUSION

This paper effectively illustrates how to develop and execute an electric vehicle battery manageme-nt system (BMS) with built-in fire safety and charge monitoring capabilities.
The ESP32 based system continuously checks the temperature, current, and state of charge (SoC) o f the battery Real-time data acquisition enables accurate estimation of SoC using the Coulomb Counting method, ensuring reliable energy tracking. Simulated discharge curves show a steady decrease in SoC under constant load conditions, while the current readings remain within acceptable operational limits

REFERENCES

1.Y. Liu, X. Qian, and H. Guan, "Development of electric vehicle battery management system with charge balance control," IEEE Transactions on Power Electronics, vol. 28, no. 6, pp. 2901-2908, Jun. 2013.

2. D. Chao, C. Shen, and K. S. Low, "Real-time state-of-charge estimation for electric vehicle batteries using a coupled electrochemical-thermal model," Journal of Power Sources, vol. 329, pp. 261-268, Jan. 2017.

3. J. Li, J. Fan, and J. Li, "A novel active cell balancing scheme for series-connected battery packs of electric vehicles," IEEE Transactions on Vehicular Technology, vol. 68, no. 5, pp. 4138 4148, May 2019.

4. D. Wang, Z. Xu, and L. Xu, "An integrated thermal management system for lithium-ion battery pack in electric vehicles," Journal of Power Sources, vol. 329, pp. 337-348, Jan. 2017.

5. H. Guo, M. H. Ang, and Y. Cheng, "Development of a fire detection system for lithium ion battery in electric vehicles," Journal of Power Sources, vol. 325, pp. 405-412, Nov. 2016.

6. M. Brandl et al., "Batteries and battery management systems for electric vehicles," 2012 Design, Automation & Test in Europe Conference & Exhibition (DATE), Dresden, Germany, 2012, pp. 971-976, doi: 10.1109/DATE.2012.6176637.

7. Y. Liu, X. Qian, and H. Guan, "Development of electric vehicle battery management system with charge balance control," IEEE Transactions on Power Electronics, vol. 28, no. 6, pp. 2901-2908, Jun.

8. D. Chao, C. Shen, and K. S. Low, "Real-time state-of-charge estimation for electric vehicle batteries using a coupled electro chemical-thermal model," Journal of Power Sources, vol. 329, pp. 261-268, Jan. 2017. 8

9. Q. Wang, B. Jiang, B. Li, and Y. Yan, “A critical review of thermal management models and solutions of lithium-ion batteries for the development of pure electric vehicles,” Renewable and Sustainable Energy Reviews, vol. 64, pp. 106–128, 2016.

10. M. Chen and G. A. Rincon-Mora, “Accurate electrical battery model capable of predicting runtime and I-V performance,” IEEE Transactions on Energy Conversion, vol. 21, no. 2, pp. 504–511, Jun. 2006.

11. G. L. Plett, “Extended Kalman filtering for battery management systems of LiPB-based HEV battery packs: Part 1. Background,” Journal of Power Sources, vol. 134, no. 2, pp. 252–261, Aug. 2004.

12. S. Santhanagopalan and R. E. White, “Quantifying cell-to-cell variations in lithium ion batteries,” International Journal of Electrochemistry, vol. 2012, Article ID 395838, 2012.

13. J. Sun, X. Wang, and Z. Zhang, “Gas detection-based early warning method for thermal runaway in lithium-ion batteries,” Journal of Power Sources, vol. 510, p. 230372, 2021.