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Battery Management System

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Abstract - This project presents the design and implementation of an advanced Battery Management System (BMS) for Electric Vehicles (EVs) using the ATmega328P microcontroller. The system integrates current and voltage sensors to monitor real-time battery parameters, displaying them on an LCD screen. Additionally, it employs a DHT11 sensor for temperature monitoring to ensure the battery operates within safe thermal limits. If the temperature exceeds a critical threshold, the system automatically suspends charging to prevent overheating. Once the battery is fully charged, the BMS disconnects the charging circuit to protect the battery from overcharging. This comprehensive approach enhances battery safety, performance, and longevity, contributing to the reliability and efficiency of EVs.

***Key Words*:** Smart BMS, State of Charge, Fire Protection

1.INTRODUCTION

Electric Vehicles (EVs) represent a significant step forward in the quest for sustainable transportation solutions, offering reduced emissions and improved energy efficiency compared to traditional gasoline-powered vehicles. Central to the effective operation of EVs is the Battery Management System (BMS), a sophisticated technology designed to monitor, manage, and protect the battery pack, which is the heart of any electric vehicle.

This project is focused on the development of an advanced BMS using the ATmega328P microcontroller, aiming to improve the monitoring and safeguarding of EV batteries. The BMS is engineered to handle several critical functions essential for the reliable and safe operation of the battery pack. These functions include real-time tracking of the battery's voltage, current, and temperature, which are crucial parameters that influence the battery's health and performance.

To achieve precise monitoring, the system employs current and voltage sensors that continuously measure the electrical parameters of the battery. The data collected from these sensors is then displayed on an LCD screen, providing users with immediate and clear information about the battery's status. Additionally, the incorporation of the DHT11 sensor allows the system to monitor the battery's temperature during charging and discharging cycles. This temperature monitoring is particularly important for preventing thermal runaway, a dangerous condition where the battery overheats and can potentially cause a fire or explosion.

One of the standout features of this BMS is its ability to automatically halt the charging process if the battery temperature exceeds a predefined threshold. This safety mechanism ensures that charging only resumes once the battery temperature returns to safe levels, thereby preventing overheating and prolonging the battery's lifespan. Furthermore, the BMS includes a function to disconnect the charging circuit when the battery is fully charged, preventing overcharging and thus enhancing battery longevity and efficiency.

Overall, this project seeks to demonstrate how an integrated BMS with advanced monitoring and control capabilities can significantly enhance the performance, safety, and reliability of electric vehicle batteries. By leveraging the ATmega328P microcontroller and various sensors, the developed system aims to address key challenges in EV battery management, providing a robust solution that supports the wider adoption and success of electric vehicles.

2. LITERATURE REVIEW

Dr. T. V. V. Pavan kumar, U. Rajendra, G. Varaprasad, G. Suryaprakash, T. Sadanand, Vinay Kumar Awaar and Surya Prakash Gairola[1], have presented an outline of the most recent headways in EV BMS innovation, explicitly zeroing in on temperature and fire security highlights. These frameworks integrate complex sensors and calculations to constantly screen the battery's temperature and manage it inside safe cutoff points. They found that temperature tracking and hearth safety functions are crucial to the green and secure operation of domestic battery control structures. By constantly monitoring battery temperature and detecting ability fireplace dangers, the BMS can optimize battery performance, expand its lifespan, and drasticallylessen the hazard of hearth-associated accidents.

Y.Mastanamma, Bhukya Laxman, A. Archana, K.Pulla Reddy[2], have presented an integrated approach to manage EV battery systems, which combines a Battery Management System (BMS) with charge monitoring and fire detection. The system is built to continuously monitor the battery's voltage, current, and temperature and to immediately turn off the battery's input or output if any unexpected behaviour is noticed. They found that the technology created will not only keep an eye on the battery and charge it securely, but it will also guard against accidents. The system's charging and monitoring circuitry is activated when it is turned on, enabling the user to safely charge the 3S battery. The current sensor monitors battery current when it is connected to a load and displays the parameter on the LCD Display.

B. V. Manikandan, P. Kiruthickroshan, M Vasantha kumar. L, Chandrasekeran [3], have presented an a real-time Battery Monitoring System(BMS) employing the method for State of charge(Soc) and displaying the vital parameters. The suggested

BMS is implemented on a hardware platform using the Arduino environment, the proper sensing technology, a central processor, and interface devices.They found that the development of an embedded battery monitoring system for electric vehicles was covered in this project.The process of system development entails creating the embedded user interface and hardware for the battery monitoring. By using sensors and LCS, the system can identify coordinates and display them in the Google Maps app, as well as display information like location, battery life, and time. By creating a smartphone application that assists users in keeping track of their battery, the system will eventually be accessible on cell phones.

SAI Durga Prasad K, Kushal G. C, Basavaraj D. Harijan, Medar Sandeep Basavaraj,Prof. Sowmya G[4], have presented an monitors the Parameters, determine SOC and provide necessary services to ensure safe operation of battery. The proposed system only monitor the battery and charge it safely but also protect it to avoid accidents from occurring. They found that the supplying crucial safety features like temperature control, fault detection, cell balancing, and fire prevention, the system lowers the possibility of battery fires and enhances the overall efficiency of electric vehicles.A few potential future work areas include eenhancing the precision and dependability of battery monitoring systems to deliver more accurate and timely data regarding the charge, health, and function of the battery pack.

Dr. Michael Hays, Cummins, Dr. Rajendra Arora, Dr. Pedro Moss[5], have presented an a temporary solution was installed instead at the sponsor's suggestion in the form of a manual switch for activating and deactivating the generator. While this prevents the design from being truly automatic, it is a feature that can be fixed by future design teams. The design teams added power supplies to the design to allow the generator to drive the vehicle, and designed and implemented an intricate system of cabling and microcontroller-driven relays to ensure only the appropriate systems would activate when called upon, and to isolate the batteries from the motor when the generator is active.

Dr. G. Jeevagan navukarasu lenin, Mrs. B neeraja, Aniket bhagirath Jadhav, Rashima Mahajan, Fernando flores-benitez,Dr. Sandeep sharma[6], have presented an in order to keepthe battery, voltage, current and ambient temperature in a stable condition, a variety of monitoring approaches are used. They found that the maximum battery capacity, battery health, and battery charge are all discussed in this study.focuses on the study of BMS and optimizes the power performances of electric vehicles. Moreover, the target of reducing greenhouse gases can greatly be achieved by using a battery management system.

ME Student,(Electronics & Tele-communications) SVPM"s COE,Malegaon (Bk), Savitribai Phule Pune University, Pune (Electronics & Tele-Eommunications Dept.) SVPM"s COE Malegaon (Bk), Savitribai Phule Pune University, Pune[7], have presented an the monitoring circuits would normally provide inputs to protection devices which would generate alarms or disconnect the battery from the load or charger should any of the parameters become out of limits.They found that this project makes it possible to build complex and effective products at a cheaper price. Application of the same for different types of hybrid vehicles and other battery using applications. The battery management system can be Used in automation industries, automotive industries etc.

Rakshitha Ravi[8], have presented an the need of electric vehicle began the revolution from traditional gasoline-powered vehicles to electric vehicles (EVs). An electric vehicle uses electric traction motors for propulsion. It could also be powered through a collector system by electricity from off-vehicle sources or could also be self-contained with a battery, solar panels, or an electrical generator to convert fuel to electricity. They found that the Global warming is effective with electric vehicles because of no emissions of gases.Limitations are the installed charging stations are not able to meet the increasing charging demand of Electric Vehicles. So, if that is overcome then effectively electric cars can be into effect.

Rui Hu University of Windsor[9], have presented an the background of electric vehicles, lithium-ion batteries and the BMS. An improved battery model was proposed in this work by considering the selfdischarging effect, the temperature effect and the fading-capacity effect observed in all batteries. The model was simulated using Matlab/Simulink, and the simulation results were discussed.They found that the results from a simulation based on an actual Thundersky battery were compared with the results from the experiments on the BMS hardware system.

M. Siva Ramkumar,C. Subba Rami Reddy, Agenya Ramakrishnan, K. Raja, S. Pushpa, S. Jose,and Mani Jayakumar[10], have presented an functions of BMS in elections vehicles are explained. e BMS consists of number of electronics components for monitoring and controlling the functions of batteries in electrical vehicles (EVs).When charging and discharging processes are controlled, the usage of energy in the battery is also controlled. &is process improves the life time of the battery and efficiency of the EV.

3. HARDWARE AND SOFTWARE USED

Hardware :

- Atmega 328P MCU
- Voltage Sensor
- Current Sensor
- DHT 11 Sensor
- 5V Relay Module
- LCD 16X2
- LM317
- BD140
- Buzzer
- Switch

Software :
- Arduino IDE

4. METHODOLOGY

4.1 Working :

System Overview: The BMS is a safety-critical system designed to manage the charging process of batteries in a vehicle. It utilizes sensors and an MCU to monitor various parameters related to battery condition and ensures safe charging.

Monitoring and Control Process: Upon initialization, the system reads data from the current sensor, voltage sensor, and temperature sensor. The ADC converts the analog sensor outputs into digital format for further processing. The MCU analyzes the sensor data to assess the battery's condition, including current flow, voltage level, and temperature. If the battery temperature deviates from the standard or threshold value, indicating a potential safety risk, the system automatically cuts off the output supply to prevent overheating and mitigate the risk of fire or explosion. The LCD displays the monitored parameters and sensor values in real-time, providing visual feedback to the user.

Safety Features: The primary focus of the BMS is to ensure the safety of the battery charging process. It incorporates safety mechanisms to prevent overheating and potential hazards associated with battery malfunction. In case of abnormal conditions detected by the sensors, such as high temperature or overcurrent, the system takes proactive measures to protect the battery and surrounding components.

User Interaction: The LCD display provides a user-friendly interface for monitoring battery parameters. Users can easily visualize the current, voltage, and temperature readings, allowing for real-time assessment of the battery's condition. In the event of a safety concern, the system communicates warnings or alerts through the LCD interface, prompting users to take appropriate action.

Integration with MCU and ADC: The sensors are connected to the MCU, which serves as the central processing unit of the system. The ADC facilitates the conversion of analog sensor signals into digital format, enabling precise measurement and analysis by the MCU. This integration ensures efficient data processing and control of the charging process, enhancing the overall performance and reliability of the BMS.

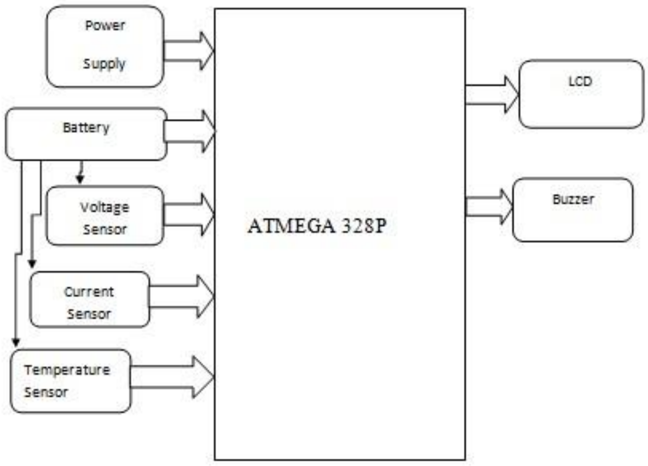

Fig.4.1.1 Block Diagram of BMS

4.2 Flowchart

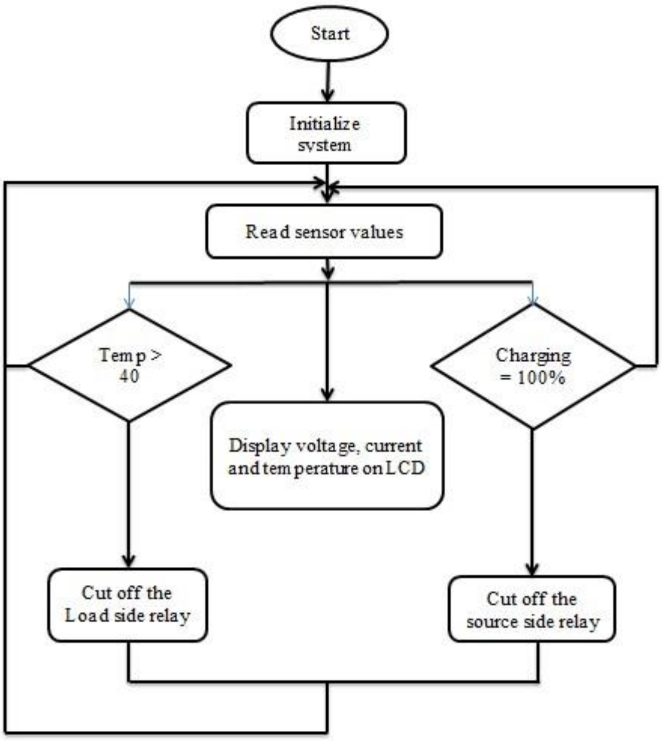

Fig.4.2.2 Flowchart of BMS

Initialization (Start): The system initializes, preparing for the monitoring and control process.

Input Stage:
- Read Sensor Data: Voltage and current sensors, along with the DHT11 temperature sensor, collect data from the battery and its surroundings.

Data Processing:
- Microcontroller (MCU): The ATMEGA 328P Microcontroller processes the sensor data.
- Display on LCD: The MCU displays the real-time values of current, voltage, and temperature on the LCD screen.

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Decision Making:

- Temperature Check: If the temperature reading exceeds 40 degrees Celsius, indicating potential overheating, the MCU triggers the load side relay to cut off power temporarily, ensuring safety.
- Charging Status Check: When the charging process reaches 100%, the MCU commands the source side relay to cut off power, indicating that charging is complete.

Output Control:

- LCD Display: The LCD screen shows the current status of the battery parameters (current, voltage, temperature) and any relevant notifications.
- Relay Control: The relays manage the flow of power, either to the load side or the source side, based on the temperature and charging status.

Feedback Loop:

- Continuous Monitoring: Sensors continuously monitor the battery parameters and environmental conditions.
- Dynamic Control: The MCU dynamically adjusts relay operations based on real-time data, ensuring efficient and safe charging.

Safety Features:

- Over-temperature Protection: The system safeguards against overheating by cutting off power if the temperature exceeds the safety threshold.
- Over-charge Protection: Charging is automatically terminated when the battery reaches full capacity, preventing overcharging and potential damage.

User Interaction:

- LCD Interface: Users can interact with the system through the LCD interface, which provides clear visual feedback on battery status and charging progress.

System Integrity:

- Reliability: The system ensures reliable monitoring and control of the charging process, maintaining the integrity of the battery.
- Safety Assurance: By implementing safety features and protective measures, the BMS prioritizes the safety of both the battery and the surrounding environment.

End (Termination):
The flowchart concludes once the charging process is complete and the system returns to standby mode, ready for future charging cycles.

5. RESULT & DISCUSSION

	Source Relay	**Load Relay**	**Buzzer**
Charging Started	On	On	On(2sec)
Normal battery temperature	On	On	Off
Battery temp. above threshold	Off	Off	On(1 sec)
Voltage above threshold	Off	On	On(5 sec)

Table 5.1 Result of BMS

Charging Level	**Voltage**
100%	16.00 V
90%	15.60 V
80%	15.10 V
70%	14.85 V
60%	14.60 V
50%	14.40 V
40%	14.25 V
30%	14.10 V
20%	13.95 V
10%	13.80 V

Table 5.2 Battery state of charge

6. ADVANTAGES AND APPLICATIONS

6.1 Advantages

The Battery Management System (BMS) offers several advantages:

Enhanced Safety: BMS ensures the safe operation of the battery by monitoring critical parameters such as temperature, voltage, and current. It protects against overcharging, over-discharging, overheating, and short circuits, thereby reducing the risk of battery failure or thermal runaway.

Improved Battery Performance: By actively managing the charging and discharging process, BMS optimizes battery performance and prolongs its lifespan. It ensures uniform cell balancing, which prevents capacity imbalances and extends the overall battery life.

Increased Efficiency: BMS helps maximize the efficiency of the battery system by preventing energy losses due to overcharging, undercharging, or inefficient cell operation. It also minimizes energy wastage by optimizing charging and discharging processes.

6.2 Applications

Electric Vehicles (EVs) and Hybrid Electric Vehicles (HEVs): Electric vehicles, including hybrid electric vehicles, rely on high-performance battery packs to power their electric motors. BMS plays a pivotal role in managing these battery systems to ensure optimal performance, safety, and longevity. In EVs, the BMS monitors critical parameters such as state of charge (SOC), state of health (SOH), temperature, and voltage of individual battery cells. It regulates charging and discharging processes to prevent overcharging, over-discharging, and thermal runaway, thereby safeguarding the battery pack and enhancing its lifespan. Additionally, BMS facilitates active cell balancing to mitigate performance disparities among battery cells, optimizing energy utilization and maximizing vehicle range. Without BMS, the efficiency, reliability, and safety of electric and hybrid vehicles would be compromised, impacting their widespread adoption and usability.

Renewable Energy Storage Systems: Battery-based energy storage systems (BESS) are integral components of renewable energy installations, such as solar and wind power plants. These systems store excess energy generated during periods of high renewable energy production and discharge it during times of high demand or when renewable sources are unavailable. BMS is essential for managing the charging and discharging of batteries in BESS, ensuring efficient energy storage and retrieval. By monitoring parameters like SOC, SOH, temperature, and voltage, BMS optimizes battery performance and protects against overcharging, over-discharging, and thermal issues. Furthermore, BMS enables dynamic control of energy flow, allowing operators to maximize grid stability, minimize energy costs, and enhance the reliability of renewable
energy systems. Without BMS, the integration of battery storage in renewable energy projects would be impractical, limiting the scalability and effectiveness of renewable energy solutions.

7. CONCLUSION & FUTURE SCOPE

7.1 Conclusion :

In conclusion, the Battery Management System (BMS) project stands as a pivotal advancement in the domain of battery technology, particularly within the context of electric vehicles and renewable energy systems. By seamlessly integrating cutting-edge monitoring, control, and safety functionalities, the BMS not only ensures the optimal performance of lithium-ion batteries but also addresses critical concerns related to safety, efficiency, and longevity. Its multifaceted capabilities empower industries to harness the full potential of battery technology while mitigating risks associated with overcharging, overheating, and other operational hazards. Moreover, the versatility of the BMS extends its applicability across diverse sectors, ranging from automotive to renewable energy, thereby ushering in a new era of sustainable energy solutions. As ongoing research and development efforts continue to refine and expand the capabilities of the BMS, its significance in driving the transition towards cleaner and more efficient energy systems becomes increasingly evident. Thus, the BMS project represents not only a technological breakthrough but also a pivotal step towards realizing a greener and more sustainable future.

7.2 Future Scope :

The future scope of Battery Management Systems (BMS) is vast and promising, with several key areas poised for significant advancements. Firstly, the integration of artificial intelligence and machine learning algorithms will enhance predictive maintenance, allowing for real-time diagnostics and prognostics of battery health, which can significantly extend battery life and performance. Secondly, the development of more advanced thermal management systems will further prevent overheating and improve overall safety. Additionally, BMS technology will increasingly support faster charging capabilities, making electric vehicles more convenient for users. Innovations in battery chemistry, such as solid-state batteries, will also drive the evolution of BMS to adapt to new battery types with different characteristics and requirements. Furthermore, BMS will play a crucial role in vehicle-to-grid (V2G) technologies, enabling EVs to interact with the power grid more effectively, contributing to energy storage solutions and grid stability. As the demand for electric vehicles grows, the future BMS will become even more sophisticated, supporting higher efficiency, enhanced safety, and greater reliability in EV operations.

8. REFERENCES

1. Dr. T. V. V. Pavan kumar, U. Rajendra, G. Varaprasad, G. Suryaprakash, T. Sadanand, Vinay Kumar Awaar and Surya Prakash Gairola, “EV BMS With Temperature and Fire Protection”, E3S Web of Conferences , 011 (2023) ICMPC 2023 https://doi.org/10.1051/e3sconf/202343001163, 2023.
2. Y. Mastanamma, Bhukya Laxman, A. Archana, K.Pulla Reddy, “EV BMS With Charge Monitor and Fire Detection”, E3S Web of Conferences 472, 03006 (2024) ICREGCSD 2023 https://doi.org/10.1051/e3sconf/202447203006, 2023.
3. B. V. Manikandan, P. Kiruthickroshan, M. Vasantha kumar. L, Chandrasekeran, “BATTERY MANAGEMENT SYSTEM WITH CHARGE MONITOR AND FIRE PROTECTION FOR ELECTRICAL DRIVE”, E3S Web of Conferences 387, 01002 (2023) ICSERET-2023 https://doi.org/10.1051/e3sconf/202338701002, 2023.
4. SAI Durga Prasad K, Kushal G.C, Basavaraj D. Harijan, Medar Sandeep Basavaraj, Prof.Sowmya G, “EV BMS WITH CHARGE MONITOR AND FIRE PROTECTION”, © 2023 IJCRT | Volume 11, Issue 5 May 2023 | ISSN: 2320-2882, 2023.
5. Dr. Michael Hays, Cummins, Dr. Rajendra Arora, Dr. Pedro Moss, “Battery Management System”, Spring 2016 http://batteryuniversity.com/learn/article/battery_management_system, 2016.
6. Dr. G. Jeevagan navukarasu lenin, Mrs. B neeraja, Aniket bhagirath Jadhav, Rashima Mahajan, Fernando flores-benitez,Dr. Sandeep sharma, “Role of Battery Management System on the Performance of Electric Vehicles”, ISSN 2063-5346 DOI: 10.48047/ecb/2023.12.si4.1541, 2023.
7. ME Student,(Electronics & Tele-communications) SVPM”s COE,Malegaon (Bk), Savitribai Phule Pune University, Pune (Electronics & Tele-Eommunications Dept.) SVPM”s COE Malegaon (Bk), Savitribai Phule Pune University, Pune, “BATTERY MANAGEMENT SYSTEM IN ELECTRIC VEHICLE”, (ICRTESM-17) ISBN:978-93-86171-12-2 01st-02nd April 2017, www.conferenceworld.in, 2017.
8. Rakshitha Ravi, “Battery Management Systems (BMS) for EV: Electric Vehicles and the Future of Energy-Efficient Transportation”, DOI:10.4018/978-1-7998-7626-7.ch001 https://www.researchgate.net/publication/350389634, 2021.
9. Hu University of Windsor, “Battery Management System For Electric Vehicle Applications”, ISBN: 978- 0-494-76296-7 https://scholar.uwindsor.ca/etd/5007, 2011.
10. M. Siva Ramkumar,C. Subba Rami Reddy, Agenya Ramakrishnan, K. Raja, S. Pushpa, S. Jose,and Mani Jayakumar, “Review on Li-Ion Battery with Battery Management System in Electrical Vehicle”, Hindawi Advances in Materials Science and Engineering Volume 2022, Article ID 3379574, https://doi.org/10.1155/2022/3379574, 2022.