e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 1, April 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.521

6381 907 438 6381 907 438 ijmrset@gmail.com www.ijmrset.com

International Journal Of Multidisciplinary Research In Science, Engineering and Technology (IJMRSET)

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| | Monthly Peer Reviewed & Refereed Journal |

|| Volume 7, Issue 1, April 2024 ||

International Conference on Recent Development in Engineering and Technology – ICRDET 24

Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, Tamilnadu, India

Integrating Electric Vehicles with Battery Management Systems Using Solar Power

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ABSTRACT: Thispaperpresentsacomprehensiveapproachtointegrateelectricvehicles (EVs) with Battery Management Systems (BMS) using solar power, aiming to address the growing demand for sustainable transportation solutions. The project focuses on harnessing solar energy to charge EVs efficiently through a robust BMS, thereby reducing reliance on conventional energy sources and minimizing carbon emissions associated with transportation. Thepaperoutlines theproject's objectives, methodology, system design considerations, and key components involved. It discusses the solar power integration process, emphasizing charge control mechanisms and voltage regulation techniques to optimize charging efficiency. Furthermore, it highlights the significance of BMS functionality in managing EV battery packs for optimal performance, safety, and longevity. A detailed integration process guide, testing procedures, and performance evaluation results are provided to validate the system's functionality and effectiveness under real-world conditions. Challenges encountered during the project implementation are addressed, along with proposed solutions and strategies for future enhancements.

KEYWORDS: Electric Vehicles, Battery Management Systems, Solar Power Integration, Sustainable Transportation, Environmental Impact Assessment.

I. INTRODUCTION

As the world transitions towards sustainable energy solutions, the convergence of electric vehicles(EVs)and renewable energy sources has emerged as a pivotal a venue in there alm of transportation. 1One innovative approach in this domain is the integration of EVs with Battery Management Systems (BMS) using solar power. This integration represents a significant step towards enhancing the efficiency, sustainability, and autonomy of electric vehicles while minimizing their environmental footprint. At its core, this integration leverages solar panels toharness theabundantenergyfromthesun. Thesesolarpanels are strategically installed on various surfaces of the EV, such as the roof or hood, to maximize exposure to sunlight. The captured solar energy is then converted into electrical power, which is utilized to charge the EV's battery pack. The BMS ensures optimal charging and discharging of the battery cells, thereby extending their lifespan and maintaining their efficiency. By interfacing with the solar charging system, the BMS orchestrates the flow of solar-generated electricity into the battery, balancing the demands of charging with the availability of sunlight. Furthermore, the integration of solar power with BMS-equipped EVs promotes energy resilience and reliability. By tapping into a decentralized energy source likesolar,EVownerscan mitigatetheeffectsofpoweroutagesordisruptionsin the grid infrastructure. This resilience is crucial for ensuring uninterrupted mobility, especially during emergencies or natural disasters.

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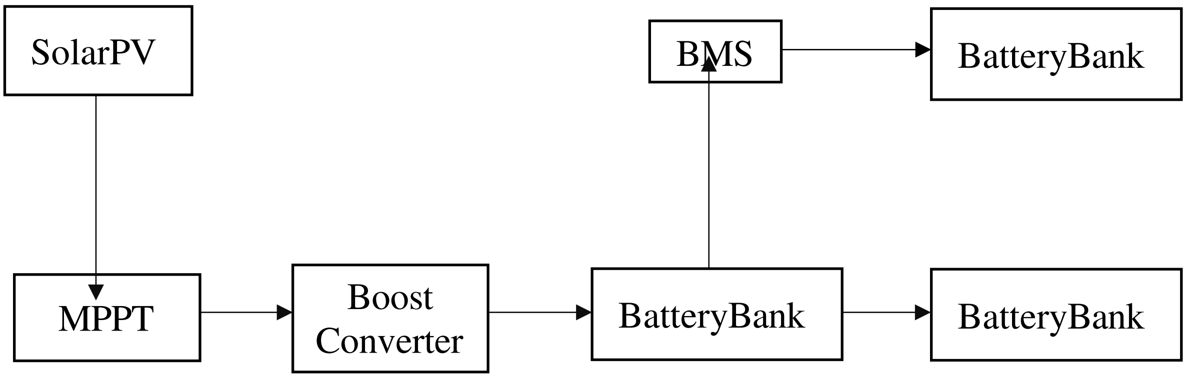
II. BLOCKDIAGRAM

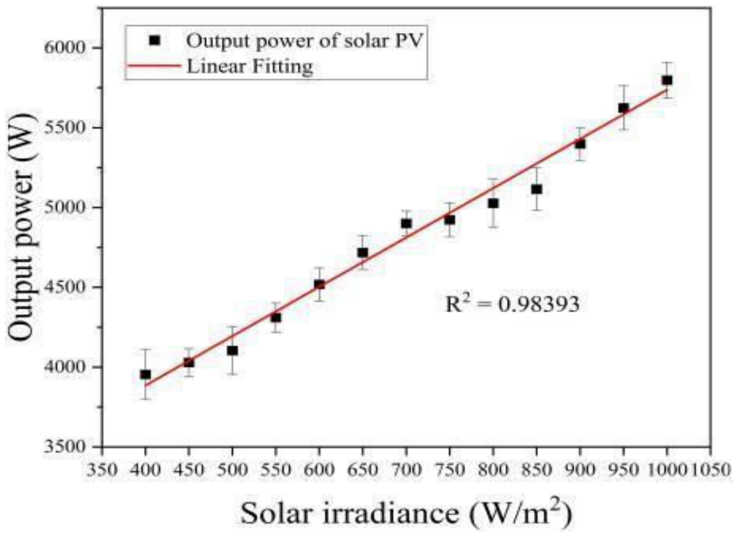


- Solar Panels: The solar panels capture sunlight and convert it into electrical energy.
- Solar Charge Controller: Regulates the voltage and current fromthe solar panels to ensure optimal charging of the batteries.
- Battery Pack: Stores the electrical energy generated by the solar panels and powers the electric vehicle.
- BMS (Battery Management System): Monitors and manages the battery pack's state of charge (SOC), state of health (SOH), and temperature to ensure safe and efficient operation.
- Battery Balancing Circuit: Balances the charge levels of individual cells within the battery pack to maximize performance and lifespan.
- Electric Vehicle Controller (EVC): Manages the power flow between the battery pack and the electric motor to propel the vehicle.
- Onboard Charger: Charges the battery pack from the solar panels or an external power source when needed.
- Vehicle Control Unit (VCU): Coordinates various vehicle systems, including the electric motor, brakes, and safety features.
- Power Conversion Unit (PCU): Converts the DC power from the battery pack into AC power to drive the electric motor.
- This integrated system ensures efficient utilization of solar energy to charge the EV's battery pack while also providing monitoring and management capabilities through the BMS to optimize performance and prolong battery life.

III. OUTPUT

Impact of solar irradiance on the output power of solar panels

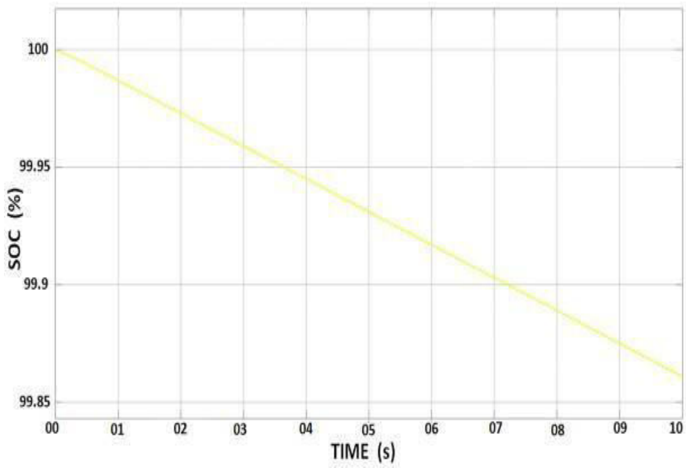
Solar irradiance is the amount of solar power received per unit area, which varies based on several influencing factors such as geographic location, time of day, seasonal changes, and atmospheric conditions. The findings reveal that the solar panel output power increases linearly by 47% when the solar irradiance increases from 400 $W/m^2$to 1000 W/m^2. The relationship between solar irradiance and output power demonstrated a linear correlation, with an R^2value of 0.98393, as depicted. This result underscores the necessity of installing solar panels in locations exposed to the highest irradiance levels.



Energy storage system for EV charging

SO Cof energy storage system after capturing energy from the solar panel, the MPPT system channels the power before sending it to the ESS for storage. Since solar panel output fluctuates due to variations in sunlight intensity, temperature, and other environmental conditions, operating at peak efficiency is impossible. The MPPT rectifies this by continuously monitoring and adjusting the solar panels' voltage and current to perform at the maximum power point.

After optimization by the MPPT, the output power increased to 6.45 kW, a growthof11.2%, with a solar irradiance of 1000W/m^2 and solar temperature of 25°C. However, despite this optimization, the SOC of the ESS declined slightly from 100% to 99.86%



IV. CONCLUSION

- The BMS ensures efficient charging of the EV's battery pack by managing the flow of solar energy , maximizing the use of renewable energy sources.
- Through continuous monitoring of battery health and temperature, the BMS helps prolong the lifespan ofthebatterypack, reducing the need for premature replacements and lowering overall maintenance costs.

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- TheBMSenhancessafetybyactivelymonitoringandmanagingthebattery pack's state of charge and temperature, thereby minimizing the risk of overcharging, overheating, and other potential safety hazards.
- By harnessing solar energy to power electric vehicles, the integrated system reduces reliance on fossil fuels and helps lower greenhouse gas emissions, contributing to a cleaner and more sustainable transportation ecosystem.
- Utilizing solar energy for charging can lead to cost savings over time by reducingrelianceongridelectricityandminimizingfuelexpenses,making electric vehicles more economically attractive for consumers and businesses alike.
- Over all, the integration of a BMS with an EV and a solar charging system represents a holistic approach to sustainable transportation, combining renewable energy sources with advanced battery management technology to create a more efficient, reliable, and environmentally friendly mobility solution.

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