DUAL BATTERY HYBRID ELECTRIC VEHICLE WITH SOLAR ENERGY OPTIMIZATION

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ABSTRACT:
Electric vehicles (EVs) are emerging as a sustainable alternative to conventional fuel-based transportation. However, one of the limitation of EVs is their restricted driving range and dependency on charging stations, which can be inconvenient for long-distance travel. To overcome this challenge, we propose a dual-battery management system integrated with solar energy to extend the vehicle's operational range and enhance energy efficiency. The system consists of two batteries: a main battery and an auxiliary battery. Initially, both batteries are fully charged. During vehicle operation, the main battery supplies power while gradually discharging. Once its charge level drops, the system automatically switches to the auxiliary battery, ensuring uninterrupted performance and it is done by the Arduino-based monitoring system . Simultaneously, the main battery begins recharging using solar energy, allowing for continuous energy replenishment. This cyclic process significantly increases the vehicle's range without requiring frequent stops at charging stations. By leveraging renewable solar energy, the system maximizes efficiency and minimizes reliance on external charging infrastructure. The intelligent battery management mechanism optimizes energy utilization, reducing downtime and enhancing overall sustainability. This approach improves the feasibility of long-distance EV travel while supporting the broader adoption of clean energy solutions in the transportation sector. The proposed system not only enhances battery efficiency but also reduces the environmental impact of EVs by integrating a self-sustaining energy source. By addressing key limitations in current EV technology, this innovation contributes to the transition towards greener and more efficient mobility solutions. This dual-battery management system represents a step forward in making electric vehicles more practical, reliable, and sustainable, paving the way for future advancements in renewable energy-powered transportation.
Keywords: Arduino-based monitoring system , Dual battery management system.

INTRODUCTION:
The increasing demand for sustainable transportation has led to a significant rise in the adoption of electric vehicles (EVs). As a cleaner alternative to fossil fuel-powered vehicles, EVs help reduce carbon emissions and dependency on non-renewable energy sources. However, one of the biggest challenges hindering their widespread adoption is limited driving range and reliance on charging stations, which can be inconvenient for long-distance travel. Addressing these limitations requires an efficient energy management system that optimizes power usage and integrates renewable energy sources. This research proposes a dual-battery management system with solar energy integration to extend the operational range of EVs while ensuring a continuous power supply. The system consists of two batteries: a main battery and an auxiliary battery. Initially, both batteries are fully charged. During

vehicle operation, the main battery powers the vehicle and gradually discharges. When its charge level drops to 30%, the system automatically switches to the auxiliary battery, ensuring uninterrupted operation. Simultaneously, the main battery begins recharging using solar energy, enabling continuous energy replenishment. This cyclic charging and switching mechanism significantly increases the vehicle's range, reducing dependency on external charging infrastructure. By utilizing solar power as a renewable energy source, this system minimizes reliance on grid-based electricity while promoting sustainable mobility. The proposed approach enhances energy efficiency, reduces downtime, and supports long-distance EV travel. This research contributes to the development of self-sustaining EV technology, offering an innovative solution to improve range and efficiency, ultimately accelerating the transition toward greener and more sustainable transportation.

OVERVIEW OF DUAL BATTERY HYBRID ELECTRIC VEHCILE WITH SOLAR ENERGY OPTIMIZATION:

The Solar-Powered Hybrid Vehicle System is designed to integrate renewable energy with battery storage to create an efficient and eco-friendly mode of transportation. This project utilizes solar panels to harness energy from the sun, which is stored in batteries and used to power an electric motor. An Arduino-based control system efficiently manages power distribution, ensuring optimal energy usage. Key components include solar panels for energy generation, 12V batteries for storage, voltage sensors for monitoring, an L298N motor driver for controlling motor speed, and an LCD display for real-time data visualization. The system automatically switches between solar power and battery backup using a relay module, providing seamless energy management. By reducing reliance on fossil fuels, this innovation promotes sustainability, reduces operational costs, and enhances the efficiency of electric vehicles. The integration of real-time monitoring and automated control makes it a practical and scalable solution for future transportation systems, paving the way for a more sustainable future**.**

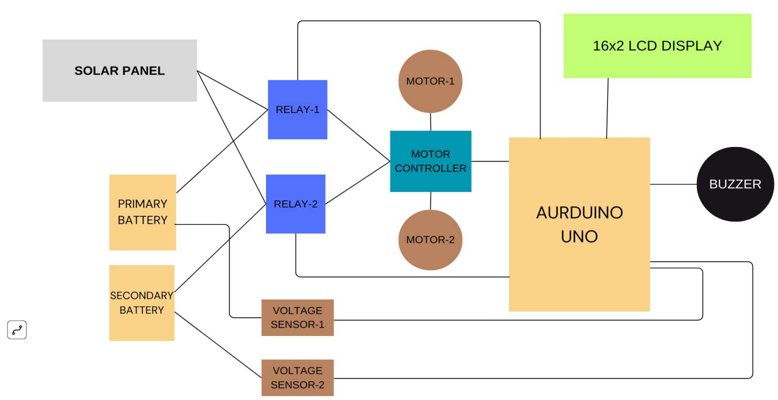

Fig.1. Block Diagram of Dual battery hybrid vehicle with solar energy optimization

A. **AURDINO UNO** : A microcontroller board that controls the entire system by processing inputs and sending output signals to various components. It reads sensor data (voltage sensors), processes it, and sends control signals to components like the relay module, motor driver, and LCD.
B. **BATTERY (12V)** : Provide power to the circuit. Two 12V batteries are used, which are monitored by voltage sensors. It powers motors via the L298N motor driver and supplies power to Arduino through voltage regulation. Voltage levels are monitored by voltage sensors.
C. **VOLTAGE SENSORS** : Measure the voltage of the batteries and send the data to the Arduino for monitoring. It monitor battery health and prevent deep discharge. Arduino reads voltage levels and can trigger alerts or switching.
D. **RELAY MODULE** : It is used to control high-power components (like motors) by switching them on or off based on signals from the Arduino. It acts as an electronic switch to control high-

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power devices and allows the Arduino to turn motors or other components on/off. It can switch between power sources (solar panel & battery).

E. **SOLAR PANEL** :It converts sunlight into electrical energy to charge the batteries or power the system. It charges batteries or directly powering the circuit and Reduces dependency on stored battery energy.
F. **LCD 16x2 Module**: Displays real-time information about voltage levels, motor status, or any other data sent by the Arduino UNO and helps the user monitor battery levels, motor status, or error messages.
G. **L298N Motor Driver**: Controls the speed and direction of the two DC motors by receiving control signals from the Arduino. It receives control signals from the Arduino. Regulates power from the battery to drive the motors and allows forward/reverse and speed control of motors.
H. **DC Motors** : These are the drive motors that move the vehicle/system. It act as the main propulsion system and receive power via the motor driver.
I. **Buzzer**: Provides an alert sound in case of specific conditions (e.g., low battery, fault detection). Alerts for low battery, system faults, or switching events.

Fig. 2 AURDINO UNO

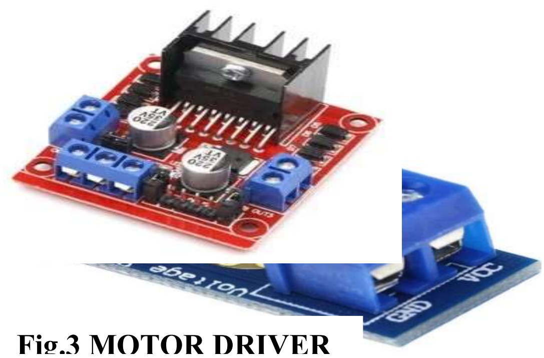

Fig.3 MOTOR DRIVER

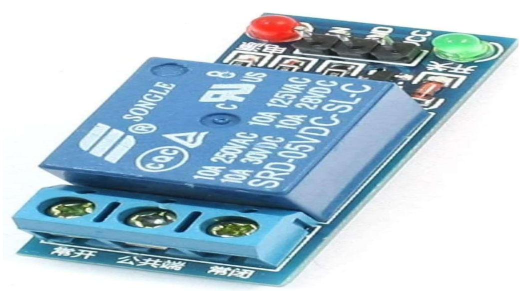

Fig . 4 RELAY MODULE

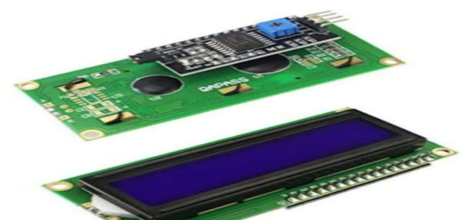

Fig .5 LCD 16*2 (I2C)

Fig . 6 SOLAR PANEL

Fig. 7 BATTERY

Fig .8 DC MOTOR

ANALYSIS AND DISCUSION :

The primary goal of this research is to implement an Dual Battery Hybrid Electric Vehicle with Solar Energy Optimization .By combining advanced monitoring technology with renewable energy sources, the aim is to extend the range of electric vehicle through the dual battery management and solar panel integartion . The integration of solar panels with electric vehicles (EVs) significantly impacts their efficiency, range, and sustainability. Our research indicates that solar-assisted EVs can extend their driving range by up to 15-25% depending on the geographical location and solar exposure. Key factors influencing performance include panel efficiency, battery capacity, and energy conversion losses. Solar panels installed on EVs generate an average of 3-5 kWh per day under optimal conditions. However, energy efficiency losses occur due to shading, temperature variations, and panel orientation.Despite the advantages, several challenges exist, such as limited surface area for solar panels restricting energy generation, efficiency drops in cloudy or shaded environments, additional weight from solar panels slightly reducing vehicle efficiency, and high initial costs and maintenance requirements. Advancements in solar cell technology, such as perovskite and tandem cells, promise higher efficiency and better integration with EVs. Battery swapping solutions can complement solar charging, addressing range anxiety and energy limitations. Policymakers and manufacturers need to collaborate to develop infrastructure and incentives for wider adoption of solar-assisted EVs. The integration of solar panels with EVs presents a promising solution for sustainable transportation. While technological and economic challenges exist, ongoing research and development will continue to enhance efficiency, affordability, and feasibility.

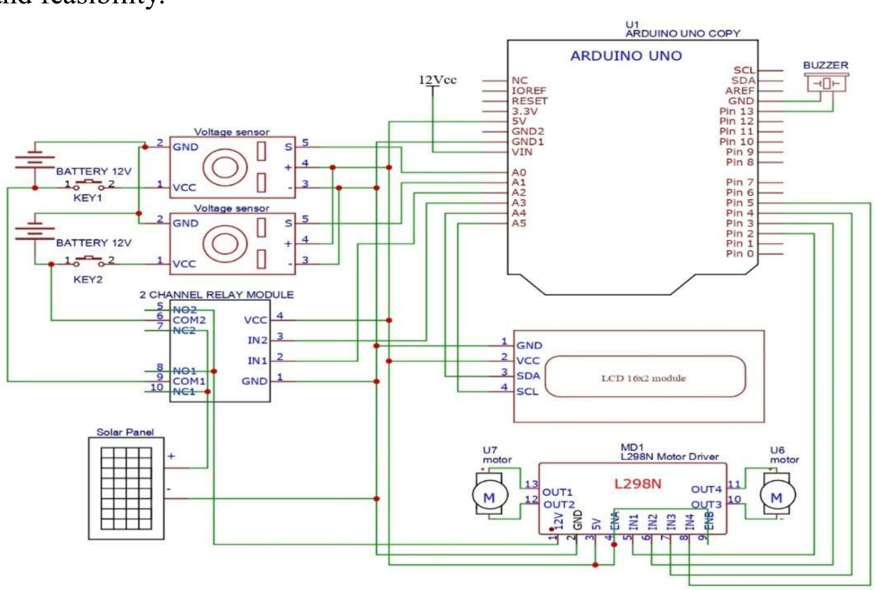

Fig.9. Architecture of the project

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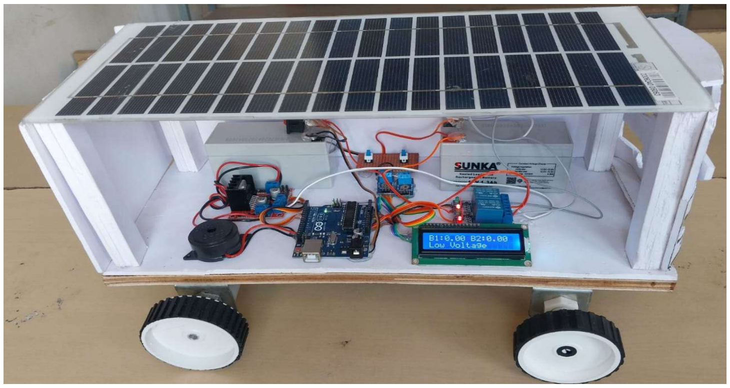

Fig.10. Side View of the Project

The model has been tested out on field under different conditions to obtain real time work results .

Case-1 : In these case the vehicle is running with main battery which is indicated with B1 and the B2 is at normal state because initially both the batteries are charged . when the battery B1 gets discharged it will be switched to battery B2 automatically .

Fig.10.a. LCD Output-1

Fig.10.b. LCD Output-2

Case-2. Now the vehicle is running with battery B2 and the battery B1 is getting charged through the solar energy . Similarly when the B2 gets discharged its get switched to battery B1 and the vehicle can travel through long distances and can also reduce dependency on charging stations.

CONCLUSION:

In conclusion the successful implementation of a Solar Electric Vehicle (SEV) System with a dual battery charging mechanism highlights its potential as a sustainable and energy-efficient transportation solution. By integrating solar energy harvesting, dual battery storage, and an intelligent power management system, this project demonstrates a practical approach to reducing reliance on conventional charging methods while optimizing energy utilization. The real-time solar charging mechanism effectively prioritizes renewable energy, ensuring continuous operation and extending the vehicle's range. The Arduino-based control system plays a crucial role in managing power distribution, minimizing energy waste, and enhancing battery longevity. Moreover, the fast-charging dual battery setup significantly reduces downtime, making the system more reliable for everyday use. By leveraging clean and renewable solar energy, this project contributes to lowering greenhouse gas emissions and reducing the overall carbon footprint of electric vehicles. The intelligent energy management strategy enhances user convenience by ensuring seamless operation with minimal dependency on grid-based charging. These features make the system an ideal solution for both urban commuting and long-distance travel, addressing key challenges in modern electric mobility. As the demand for eco-friendly transportation solutions continues to grow, this solar-powered EV system presents a scalable and cost-effective innovation for the future. With further advancements in battery technology, solar efficiency, and automation, this project lays the foundation for a more sustainable, energy-efficient, and environmentally conscious transportation system.

REFERENCES:

1. L. Situ, "Electric Vehicle development: The past, present & future," 2009 3rd International Conference on Power Electronics Systems and Applications (PESA), Hong Kong, China, 2009, pp. 1-3.
2. T. Harakawa and T. Tujimoto,"Efficient solar power equipment for electric vehicles: improvement of energy conversion efficiency for charging electric vehicles," IVEC2001. Proceedings of the IEEE International Vehicle Electronics Conference 2001., Tottori, Japan, 2001, pp. 11-16.
3. Y. He, B. Venkatesh and L. Guan, "Optimal Scheduling for Charging and Discharging of Electric Vehicles," in IEEE Transactions on Smart Grid, vol. 3, no. 3, pp. 1095-1105, Sept. 2012.
4. R. de Silva and K. Fisk, "Charging electric vehicles from distributed solar generation," 2015 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC), Brisbane, QLD, Australia, 2015, pp. 1-5.
5. M. Elshafei, A. Al-Qutub and A. -W. A. Saif, "Solar vehicle optimization for the World Solar Challenge," 2016 13th International Multi-Conference on Systems, Signals & Devices (SSD), Leipzig, Germany, 2016, pp. 751-756.
6. I. S. Bayram, "Impacts of Electric Vehicle Charging under Cold Weather on Power Networks," 2021 56th International Universities Power Engineering Conference (UPEC), Middlesbrough, United Kingdom, 2021, pp. 1-6.
7. J. M. Kharade, A. A. Patil, N. V. Yadav, B. D. Kamble and A. B. Virbhadre, "Dual Battery Charger System for Electric Vehicle," 2021 Second Iinternational Conference on Electronics and Sustainable Communication Systems (ICESC), Coimbatore, India, 2021, pp. 157-16.
8. H. Jung, H. Jang, H. Han, K. Cho, B. Kang and S. Park, "Electric Vehicle Charging System to Reduce Carbon Emissions Using Photovoltaic Power Generation and ESS," 2022 IEEE 5th Student Conference on Electric Machines and Systems (SCEMS), Busan, Korea, Republic of, 2022, pp. 1-4.
9. M. Kobbi, L. Mazouz and C. Ghenai, "Modernization, control, and energy management of an industrial electric vehicle with solar energy supply," 2022 5th International Conference on Power Electronics and their Applications (ICPEA), Hail, Saudi Arabia, 2022, pp. 1-6.
10. J. Garluna, "Measuring Solar Cell Efficiency: A Comparative Study of Energy Conversion Efficiency of Solar Cells of the Solar Electric Vehicle, STC-3 at the World Solar Challenge in Australia and at Test Drives on Sathorn Road in Bangkok, Thailand," TENCON 2022 - 2022 IEEE Region 10 Conference (TENCON), Hong Kong, Hong Kong, 2022, pp. 1-3.
11. T. Yang, H. Zhang, M. Wu and X. Tang, "Research on the Optimization Strategy of Electric Vehicle Charging and Discharging Scheduling," 2023 3rd Power System and Green Energy Conference (PSGEC), Shanghai, China, 2023, pp. 455-459.
12. P. Prajapati, J. Thankachan and A. Kumar, "Design of a PV based battery charger for a Solar assisted Electric Vehicle," 2023 7th International Conference on Computer Applications in Electrical Engineering-Recent Advances, Roorkee, India, 2023, pp. 1-6.
13. T. Guntalwar, P. Thawkar, K. Bansod and P. Ramtekkar, "Electric Vehicle Charger with Solar Backup," 2023 11th International Conference on Emerging Trends in Engineering & Technology - Signal and Information Processing, Nagpur, India, 2023, pp. 1-4.
14. V. Singh, S. Saxena, R. Kumar and S. Modem, "Automatic Battery Swapping Model for Efficient Charging of Solar-based EV," 2023 IEEE Transportation Electrification Conference and Expo, Asia-Pacific, Chiang Mai, Thailand, 2023, pp. 1-7.

