IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 3, March 2026

DOI: 10.17148/IJIREEICE.2026.14305

"Design and Implementation of a Low-Cost Hybrid Solar-Grid Charging Prototype for Electric Two Wheelers"

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Abstract: The rapid adoption of electric two-wheelers has created an urgent need for sustainable and cost-effective charging solutions. Conventional grid-based charging stations not only increase the load on the power network but also contribute indirectly to carbon emissions. To address these challenges, this project proposes the design and implementation of a lowcost hybrid solar-grid charging prototype for electric two-wheelers.

The system integrates a photovoltaic (PV) array with an. MPPT-based charge controller, a battery storage unit, and a power management circuit that enables seamless switching between solar and grid power. Under optimal conditions, the solar energy serves as the primary source of charging, while the grid acts as a reliable backup in case of insufficient solar generation.

The prototype is designed to ensure efficiency, affordability, and scalability for urban and rural applications. Simulation studies in MATLAB/Simulink validate the system's performance under varying load and weather conditions, while preliminary experimental analysis confirms its feasibility. Hybrid approach not only reduces dependency on grid electricity but also promotes the use of renewable energy in the electric mobility sector.

I. INTRODUCTION

The proposed project focuses on the design and implementation of a low-cost hybrid solar-grid charging system for electric two-wheelers. The hybrid system utilizes two sources of power: solar energy during daytime and grid electricity as a backup during low sunlight conditions, night hours, or rainy days. This dual-source approach ensures reliable, flexible, and uninterrupted charging. The primary objective of the system is to develop an affordable charging prototype that can be widely adopted in cities as well as smaller towns without requiring heavy investment.

By using solar panels to harness natural sunlight, the system helps reduce electricity bills, minimizes pollution, and decreases dependency on the conventional power grid.

With the rapid growth of electric vehicles, particularly electric two-wheelers in India, the demand for dependable and economical charging solutions has significantly increased. Conventional grid-based charging increases stress on the power system and adds to operational costs, while solar energy alone cannot provide continuous charging due to its intermittent nature. To overcome these limitations, the proposed hybrid system uses solar energy as the primary source and grid electricity as a reliable backup. This approach ensures uninterrupted charging, supports sustainable and eco-friendly transportation, reduces electricity expenses, and contributes to a greener future by promoting efficient use of renewable energy in electric mobility.

Furthermore, the proposed prototype is designed with simple control and power management mechanisms to automatically switch between solar and grid sources based on availability. This enhances system efficiency and ensures

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safe battery charging for electric twowheelers. The implementation of such a hybrid charging model can be highly beneficial for residential areas, small charging stations, and campus environments.

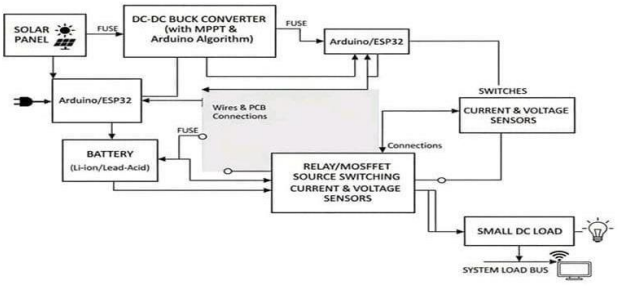
Overall, the system offers a practical, cost-effective, and scalable solution to support the growing demand for electric mobility while encouraging the adoption of renewable energy technologies.

II. METHODOLOGY

Literature Review & Requirement Analysis: Studied existing solar, grid, and hybrid EV charging systems and identified gaps related to cost, reliability, and scalability.

- System Design: Designed a hybrid architecture integrating Solar PV with grid backup and selected essential components such as PV module, MPPT controller, battery, inverter, and charger.
- Simulation & Modeling: Developed and simulated the proposed system in MATLAB/Simulink to analyze charging performance under varying solar irradiance and load conditions.
- Development: Fabricated and assembled low-cost hardware including PV panels, charge controller, battery unit, power switching system, and grid interface.
- Testing & Performance Validation: Performed experimental analysis in solar-only, grid-only, and hybrid modes to evaluate efficiency, reliability, and costeffectiveness.
- Report & Documentation: Documented the methodology, results, performance analysis, and suggested future enhancements.

III. DESIGN



1. Solar Panel – 20 W / 12 V
2. DC-DC Buck Converter (with MPPT algorithm on Arduino)
3. AC-DC Adapter / SMPS (230V to 12V, 5A)
4. Lead Acid Battery (12V, 7–10Ah) or Li-ion pack
5. Arduino Uno / ESP32
6. Current & Voltage Sensors
7. Relay Module / MOSFETs for source switching
8. LCD Display / IoT module
9. Small DC motor OR e-bike battery (load)
10. Misc (wires, PCB, casing, protection fuse, switches)

IV. CONCLUSION

The project successfully demonstrates the design and implementation of a low-cost hybrid solar-grid charging system for electric two-wheelers. The system efficiently integrates solar energy as the primary source and grid power as a backup, ensuring reliable and uninterrupted charging under varying environmental conditions. The use of an Arduino-based control system enables intelligent power management and automatic switching between energy sources, enhancing system performance. Additionally, the implementation of a Maximum Power Point Tracking (MPPT) technique improves solar energy utilization, resulting in higher efficiency compared to conventional methods. The experimental results confirm that the system operates safely, provides stable charging, and significantly reduces dependency on grid electricity. Overall, the proposed system is cost-effective, environmentally friendly, and suitable for real-world applications, contributing to the advancement of sustainable and green transportation solutions.

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ACKNOWLEDGMENT

We would like to express our sincere gratitude to our project guide**, Prof. Rajendra Bhombe,** for his continuous support, valuable guidance, and encouragement throughout the development of this project. We are also thankful to the Department of Electrical Engineering for providing the necessary resources and facilities to carry out this project successfully. We extend our appreciation to all the faculty members for their guidance and support during the course of this work. Finally, we would like to thank our teammates for their cooperation, dedication, and teamwork, which played a crucial role in the successful completion of this project.

REFERENCES

[1]. Kumar / Dwivedi, Electric Vehicle Propulsion Drives and Charging Systems (Routledge, 2024)— Modern treatment of EV charging infrastructures, onboard chargers, converters and battery-charging architectures (helpful for EV two-wheeler charging design).

[2]. S. Sharma, R. Kumar, and P. Singh, "Hybrid Solar and Grid Powered Charging Infrastructure for Electric Vehicles: A Low-Cost Design Approach," IEEE Transactions on Transportation Electrification, vol. 9, no. 2, pp. 1403–1415, June 2023.

[3]. A. Mehta and V. Patel, "Design and Implementation of Solar-Grid Hybrid Charging Station for TwoWheelers," International Journal of Renewable Energy Research (IJRER), vol. 12, no. 4, pp. 1987–1995, Dec. 2022.

[4]. R. Khan and M. Rahman, "Optimization of Hybrid Renewable Energy Systems for EV Charging," Energy Reports, Elsevier, vol. 8, pp. 556–567, Sept. 2022.

[5]. Bureau of Indian Standards (BIS), "IS 17017: Electric Vehicle Conductive Charging Systems – Part 21: General Requirements," BIS, New Delhi, 2021.

[6]. C. Wang, Y. Li, and H. Zhang, "Low-Cost Power Electronics Design for Solar-Assisted EV Chargers," Renewable and Sustainable Energy Reviews, Elsevier, vol. 160, 112307, Jan. 2022.