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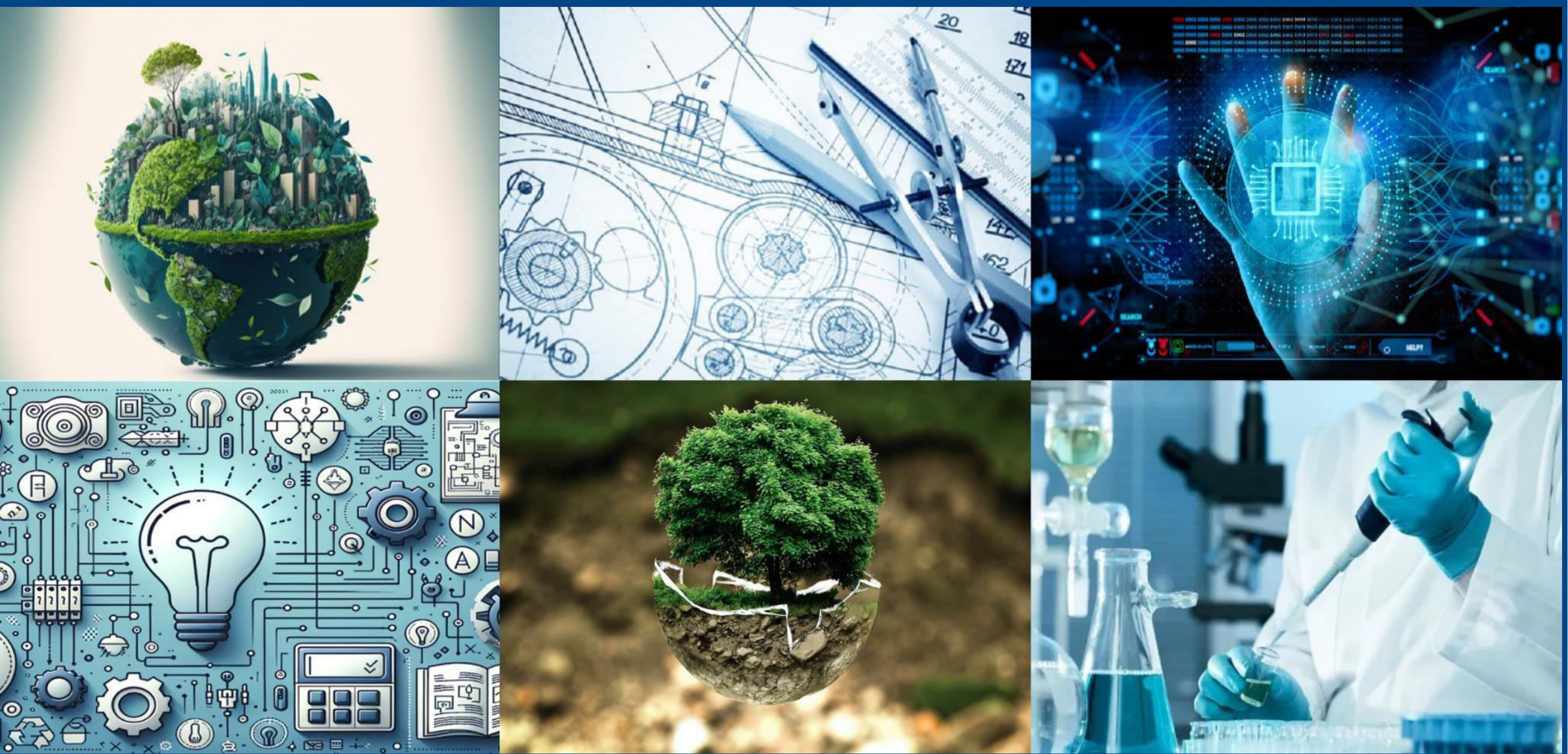

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Solar and Grid-Integrated EV Charger using Sepic Topology

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ABSTRACT: Building dependable, sustainable, and effective charging infrastructure is essential given the growing demand for electric cars (EVs).The design and execution of a hybrid EV charging system that combines grid power with solar photovoltaic (PV) energy is suggested by this project.The output is controlled by a Single Ended Primary Inductor Converter (SEPIC).The SEPIC converter was chosen because it can produce a steady DC output across a broad range of input voltages, which makes it perfect for systems with intermittent and variable energy sources like solar power and a fluctuating grid supply.By making solar energy the main power source, the system architecture lessens reliance on the traditional grid and promotes the use of renewable energy in the EV charging industry.The suggested configuration maximizes the usage of clean energy while guaranteeing continuous charging by utilizing solar energy when it is available and smoothly transitioning to grid power when required.In addition to increasing energy reliability, this hybrid setup makes a substantial contribution to lowering carbon emissions linked to electricity generated from fossil fuels.Additionally, the charging system's overall performance and efficiency are improved by using a SEPIC converter, which allows for smooth voltage management and flexibility to various input conditions without sacrificing output quality.The deployment of this hybrid system promotes the creation of environmentally friendly infrastructure and is in line with international initiatives to move toward sustainable mobility.To sum up, our initiative opens the way by showcasing a workable and expandable strategy for maximizing the use of renewable energy in EV charging.

KEYWORDS: SingleEnded Primary Inductor Converter (SEPIC), EV charging, Solar Photovoltaic energy.

I. INTRODUCTION

The increasing global emphasis on sustainable transportation has accelerated the development of renewable energy-based electric vehicle (EV) charging infrastructures. Among the available renewable technologies, hybrid solar-grid charging systems have demonstrated significant potential in addressing environmental concerns and ensuring energy reliability. The integration of photovoltaic (PV) systems with the electrical grid not only minimizes greenhouse gas emissions but also enhances system flexibility and cost-effectiveness for large-scale EV adoption [2], [3].

Power electronic converters play a vital role in efficiently interfacing renewable energy sources with EV charging units. In particular, the Single-Ended Primary Inductance Converter (SEPIC) has gained considerable attention due to its ability to provide a non-inverted output voltage, low input current ripple, and stable operation across varying solar irradiance levels [1], [4]. These characteristics make SEPIC converters highly suitable for renewable-based charging applications, ensuring reliable and continuous power delivery to EV batteries.

Recent studies have explored various energy management strategies to optimize the performance of hybrid solar-grid systems. Intelligent control mechanisms facilitate real-time power flow management, ensuring maximum solar energy utilization while maintaining grid stability and reducing operational costs [7], [8], [9]. Such adaptive control systems enhance charging efficiency, battery lifespan, and overall energy sustainability.

Furthermore, several optimization and case studies have demonstrated that hybrid solar-electric vehicle charging stations can achieve improved energy utilization, reduced dependence on grid power, and enhanced economic

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performance [5], [6]. Consequently, the integration of SEPIC converter-based energy management within hybrid charging systems presents a promising pathway toward achieving cleaner and smarter EV infrastructure.

The objective of this paper is to design and analyze a SEPIC converter-based hybrid solar-grid electric vehicle charging system, focusing on improving power conversion efficiency, ensuring stable charging performance, and implementing adaptive energy management strategies to promote sustainable mobility.

II. PROPOSED METHODOLOGY

The primary objective of this project is to design and implement a hybrid EV charging system that effectively combines solar PV and grid power using a SEPIC converter to ensure stable and efficient operation. The proposed system prioritizes solar energy usage to promote sustainability and reduce grid dependency. When solar energy is insufficient—due to low irradiance, cloud cover, or night-time conditions—the system automatically switches to grid power to maintain uninterrupted EV charging. This intelligent energy management not only improves the reliability of the charging station but also significantly contributes to lowering carbon emissions and fossil fuel consumption.

The paper focuses on optimizing the performance and efficiency of the SEPIC converter within the hybrid system. By conducting detailed simulations and hardware implementation, the system's response to varying input conditions is analyzed, and the converter's efficiency in regulating output voltage is evaluated. The use of the SEPIC converter provides several advantages: high power conversion efficiency, reduced output ripple, and better control over energy distribution. These features make it a preferred choice for integrating renewable and conventional energy sources in EV charging systems.

From a broader perspective, the successful implementation of such hybrid systems supports the global transition to sustainable transportation and aligns with international goals related to clean energy and carbon neutrality. In addition, the project contributes to enhancing the resilience and flexibility of the power grid by reducing the load during peak periods through partial reliance on solar power. As EV adoption continues to rise, scalable and environmentally responsible charging solutions like the one proposed in this project become increasingly vital.

III. BLOCKDIAGRAM

Figure.1represent the block diagram of proposed system. Fig.2 represent theCircuit Diagram of proposed system.

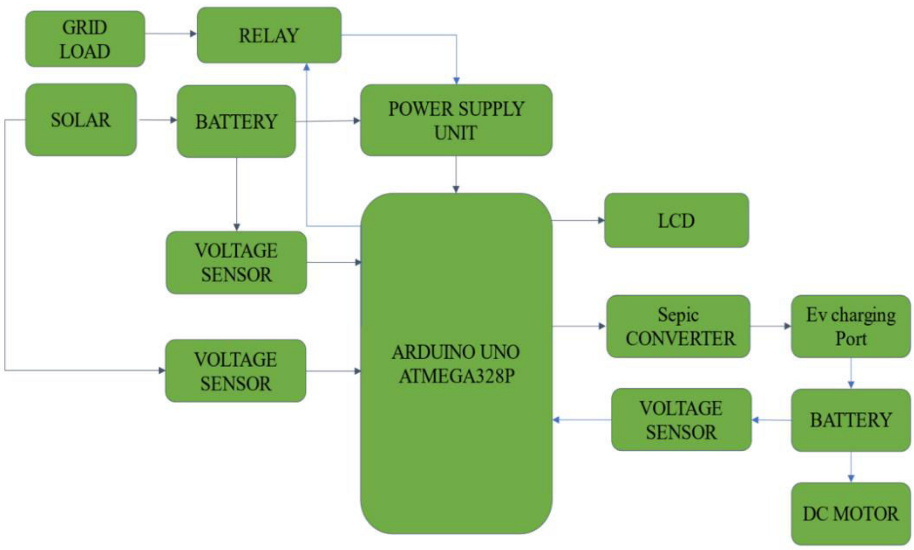

Figure.1 Block Diagram of Proposed system

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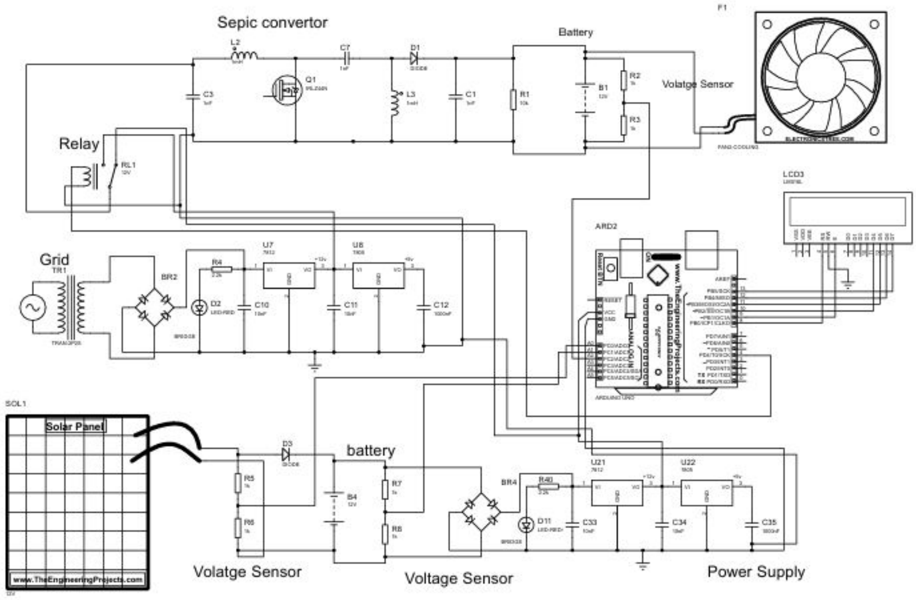

Figure.2 Circuit Diagram

IV. HARDWARE IMPLEMENTATION

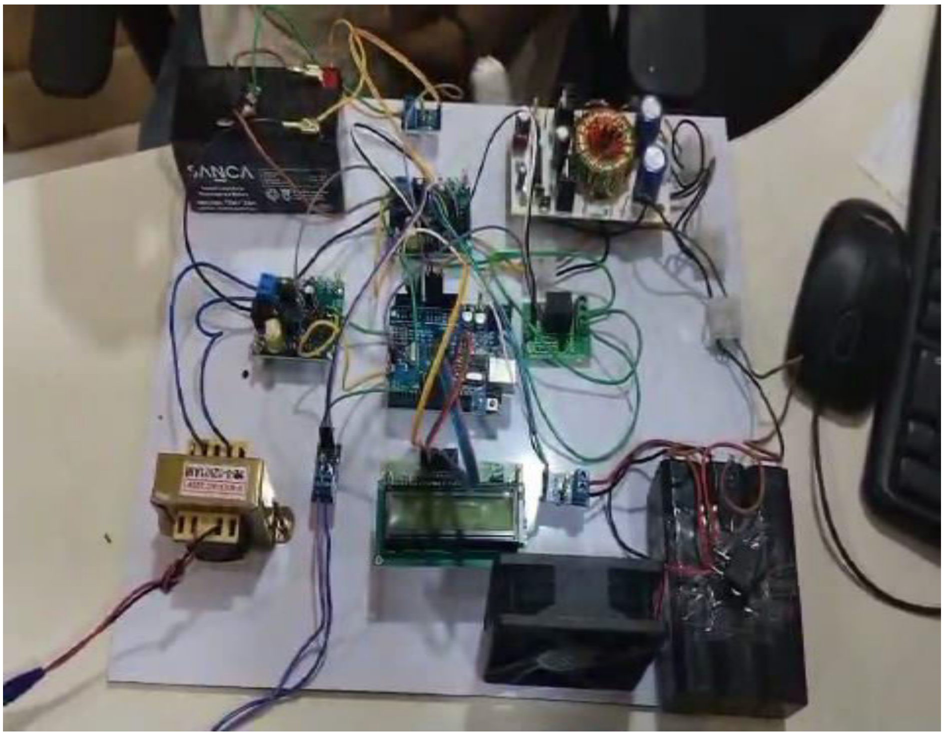

Figure 3 Hardware implemtation

This design not only optimizes the efficiency of the charging process but also contributes significantly to the globaleffort of reducing carbon emissions. By prioritizing solar energy, the system supports the transition to a cleaner andmore environmentally friendly transportation model, aligning with global sustainability goals. The hybrid nature of

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thesystem also ensures that charging is not interrupted during periods of low solar energy availability, promotingcontinuous, reliable access to charging infrastructure regardless of weather conditions.

The hybrid approach proposed in this project is scalable and can be implemented in a variety of settings, from residentialareas to large-scale commercial charging stations, furthering the integration of renewable energy into the transportationsector. As the adoption of electric vehicles continues to rise, such hybrid systems will be crucial in developing asustainable, efficient, and cost-effective charging network. Overall, this project highlights the potential of combiningsolar energy with grid power for EV charging, making significant strides toward optimizing renewable energy usage,reducing carbon footprints, and supporting the global shift toward sustainable energy practices.

V. RESULT AND DISCUSSION

The hybrid EV charging system, combining solar photovoltaic (PV) energy and grid power using a SEPIC converter,demonstrates a significant improvement in the efficiency and sustainability of electric vehicle (EV) charging. Thesystem was tested under varying environmental conditions, simulating different solar irradiance levels and grid poweravailability. The SEPIC converter successfully maintained a stable DC output, adapting seamlessly to fluctuating inputsfrom both the solar PV and grid sources. This characteristic of the SEPIC converter is crucial, as it ensures continuouscharging for EVs, even when solar power is unavailable or grid power fluctuates.

A key finding from the system's performance was the prioritization of solar energy. During daylight hours withsufficient sunlight, the system predominantly relied on solar energy for charging, reducing the overall dependency onthe grid. This not only enhanced the system's sustainability but also contributed to a significant reduction in operationalcosts, as solar power is a renewable and cost-effective resource. In scenarios where solar irradiance was insufficient,the system effectively switched to grid power, ensuring uninterrupted charging without compromising the reliability ofthe charging process.Furthermore, the SEPIC converter's wide input voltage range proved advantageous in ensuring the stability of thesystem. It allowed the hybrid setup to function efficiently under a variety of input conditions, including changes in solarpanel output due to weather variations or grid voltage fluctuations. The efficiency of the converter contributed tominimal energy loss, thereby improving the overall performance of the charginginfrastructureOverall, the proposed system supports the global transition to sustainable transportation by optimizing renewable energy.

VI. CONCLUSION

In conclusion, the proposed hybrid EV charging system utilizing solar photovoltaic (PV) energy and grid power,regulated by a SEPIC converter, offers a robust solution to the challenges faced by the growing electric vehicle (EV)infrastructure. By integrating renewable solar energy with the conventional grid, the system maximizes the use ofsustainable power sources while minimizing reliance on non-renewable energy. The SEPIC converter's ability toefficiently handle a wide range of input voltages ensures that the system remains adaptable to varying solar radiationand grid fluctuations, providing consistent and reliable DC output for EV charging applications.

This design not only optimizes the efficiency of the charging process but also contributes significantly to the globaleffort of reducing carbon emissions. By prioritizing solar energy, the system supports the transition to a cleaner andmore environmentally friendly transportation model, aligning with global sustainability goals. The hybrid nature of thesystem also ensures that charging is not interrupted during periods of low solar energy availability, promotingcontinuous, reliable access to charging infrastructure regardless of weather conditions.

The hybrid approach proposed in this project is scalable and can be implemented in a variety of settings, from residentialareas to large-scale commercial charging stations, furthering the integration of renewable energy into the transportationsector. As the adoption of electric vehicles continues to rise, such hybrid systems will be crucial in developing asustainable, efficient, and cost-effective charging network. Overall, this project highlights the potential of combiningsolar energy with grid power for EV charging, making significant strides toward optimizing renewable energy usage,reducing carbon footprints, and supporting the global shift toward sustainable energy practices.

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