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Review TEE

Mobile Electric Vehicle Charger with Fast Charging Technique

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Abstract

With the ever-increasing demand for electric vehicles (EVs), the need for efficient and user-friendly charging solutions is becoming more critical. This manuscript explores the development and impact of mobile EV charging solutions through the integration of mobile applications and fast charging technology. The proposal examines the evolution of portable, on-demand fast charging systems as essential components of EV infrastructure, including the use of renewable energy sources such as solar power. The study focuses on how mobile applications enhance these systems by providing real-time location tracking of charging units and facilitating booking capabilities. Such charging solutions significantly contribute to increasing EV adoption rates and supporting urban mobility by alleviating range anxiety. The findings suggest that mobile EV charging solutions, supported by advanced mobile apps, offer greater flexibility and convenience compared to traditional fixed charging stations. However, the study also emphasizes the need for continuous advancements in both app functionalities and charging unit technologies to ensure these systems operate effectively and integrate seamlessly into the broader EV ecosystem. With these improvements, mobile EV charging solutions can play a pivotal role in transforming the way electric vehicles are charged, ultimately driving the transition toward a more sustainable and accessible future.

Keywords: Arduino, LCD, load cell, internet of things (IoT), electric vehicles, wireless charging lanes

INTRODUCTION

In the future, most conventional vehicles will be replaced by electric vehicles (EVs) as suggested by the International Energy Agency (IEA). The International Energy Agency described two exclusive scenarios for electric mobility. In one scenario based on existing government strategies, around 140 million EVs may be in circulation by the end of this decade, where approximately 25 million new EVs are sold every year. However, there is a more advanced scenario that corresponds to the aspiration set out in the Paris Agreement, where the numbers can shoot up to 245 million EVs on the road and over 45 million sold on a yearly basis. The range limit of an electric vehicle is one of the key factors restricting EV growth owing to the existing battery technology. At present, building a greater number of charging stations to meet the charging demand of all these EVs is a huge challenge, and many researchers are conducting research on fast charging techniques. Owing to the popularity of EVs, the majority of existing research has focused on fixed charging stations. Fast charging stations alone cannot satisfy the growing EV charging demand, particularly in densely populated areas. Moreover, wireless charging technologies, including battery swapping and wireless charging lanes, lead to more space, relatively high building costs, and high

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maintenance. An effective way to keep up with the increasing EV growth is to use various charging methods with different features, such as battery swapping, charging lanes, or mobile chargers to compensate for the fast charging technique. Building mobile EVs can solve this problem. Mobile EV charging refers to the process in which EV drivers send a charge request, which includes the amount of charge and location to a charging operator, who then arranges mobile charging stations to serve customers. In addition, this fast charging method encourages EV adoption by reducing the time taken to charge and reducing range anxiety in the EV owner.

LITERATURE REVIEW

Kumar et al. [1] used a truck-based configuration to provide flexible and efficient EV charging. Integrating solar panels, lithium-ion batteries, and 50 kW DC fast charging, this innovative solution boasts 100 kWh of energy storage and 10 kWp solar capacity. Featuring real-time monitoring and control, as well as a modular design for scalability, this station is ideal for both urban and rural EV charging infrastructures. By addressing range anxiety and enhancing convenience, this mobile charging station promotes increased EV adoption, thereby supporting a sustainable transportation ecosystem. Singh et al. [2] integrated renewable energy sources with mobile EV charging stations to optimize energy harvesting and storage using solar, wind, and battery systems. This sustainable solution enhances grid resilience, reduces emissions, and ensures continuous EV charging. Key strategies include energy forecasting, load management, and smart-grid integration. Hao Tu et al.'s [3] study highlighted the need for an advanced charging infrastructure to support the growing EV market. Extreme fast charging (XFC) technology has emerged as a game-changer, enabling 10–20 minute refueling times comparable to those of gasoline vehicles. XFC boasts 400–1000 kW power levels [4], advanced cooling systems, and optimized battery designs. Yilmaz et al. [5] reviewed mobile charging stations for EVs, emphasizing their flexibility and potential in underserved areas. They explored the integration of renewable energy sources, energy storage, and advancements in the field of power electronics. The paper also addresses challenges, including high costs, efficiency, and regulatory hurdles, and suggests areas for future research. Hadji et al. [6] compared Cuk, single-ended primary-inductor converter (SEPIC), and Zeta converters for Maximum Power Point Tracking (MPPT) in photovoltaic systems. In this study, we evaluated their efficiency, complexity, and suitability. While each converter offers unique advantages such as voltage flexibility, low ripple, and stability, the optimal choice depends on specific system requirements and design considerations.

GAPS IDENTIFIED

Fixed or traditional charging stations are installed at specific locations and connected to the electrical grid, providing charging for EVs. They require significant upfront investment and maintenance and are limited to particular vehicles associated with respective companies. By contrast, mobile charging stations are portable and can be deployed anywhere, operating off-grid, or connected to a grid that is not specified for any particular vehicle. They offer flexible and convenient charging solutions suitable for emergencies, temporary, or remote charging needs. Lower upfront maintenance costs

METHODOLOGY

The system is designed to integrate and efficiently manage two power sources, AC mains, and a solar panel, ensuring reliable energy delivery to the load. Integration is a combination of various entities that optimize power usage and assist in power delivery even when one of the power sources is not available or insufficient. As seen in Figure 1, AC mains provide energy whenever there is a power shortage. It commences with a stepdown of the AC voltage through a transformer; it then cuts the AC power supply and rectifies it into DC. The controller ensured that the DC output was stable and usable. On the other hand, the solar panel draws solar energy in the form of a DC, which is further varied through a buck–boost converter and controller to apply a standard voltage, owing to the expected variations in the intensity of solar energy with respect to weather and time. In addition, a voltage controller ensures that no matter what the source of power [7–9], the output power remains the same for the load. A relay module is interfaced with an Arduino to control the flow of energy by switching the system between

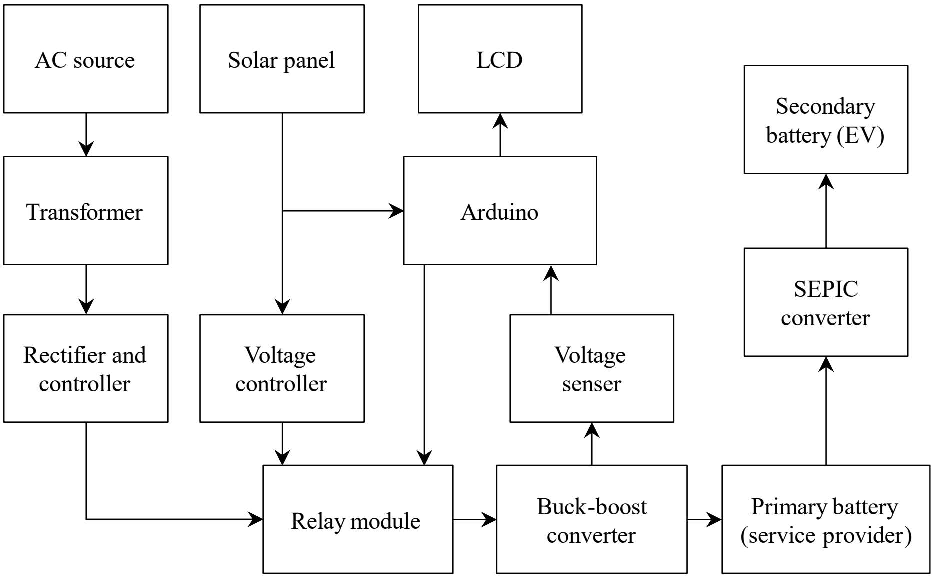

Figure 1. Block diagram of the fast charging technique model.

the AC mains and solar panels, as the two sources dictate, as shown in Figure 1. A single-ended primary inductor converter, also known as a SEPIC, alleviates the impediments of power supplied from the battery by controlling the voltage irrespective of the high or low charge located in the battery. As shown in Figure 1, the Arduino microcontroller serves as the central control unit, automating the switching process and continuously monitoring the voltage levels using a voltage sensor. It is interfaced with an LCD that offers information on the active power source, battery status, and voltage levels. The overall architecture ensures the seamless integration of renewable and conventional energy sources while maintaining system reliability and efficiency [10]. This modular and scalable design makes the system suitable for various applications, including those with an intermittent energy supply.

Process of the Proposed Work

- *Step 1:* As shown in Figure 2, the user requests a charging service. The electric vehicle owner realizes that their vehicle's battery is low/dead and needs charging. Therefore, the user opens the application and sends a request for charging assistance. This request includes the State of Charge (SoC), the current battery level of the vehicle, and the real-time location of the vehicle that the service provider needs to find.
- *Step 2: App processes the request:* The app receives the charging request from the user and forwards it to the Service Provider with all necessary details.
- *Step 3: Service provider response: Service provider:* The entity responsible for delivering the charging service. Upon receiving this request, the service provider assesses the information. They determined the estimated time of arrival (ETA) to the user's location and the total cost of providing the service. This information is then sent back to the user through the app.
- *Step 4: Charging circuit setup:* The provider prepares its charging infrastructure to charge its portable battery, which is then used to charge the user's vehicle. The charging setup involves two potential power sources: a Solar Panel/PV Cell which Converts sunlight into DC power, which is managed by a controller to charge the battery, and a Grid/AC Source, which provides AC power from the electrical grid, which is converted to DC by an Inverter to charge the battery.
- *Step 5: Power conversion for vehicle charging:* A SEPIC converter is a critical component in ensuring the correct and safe transfer of power from the battery to the user's vehicle. The voltage levels were adjusted to match the requirements of the battery of the discharged vehicle.
- *Step 6: Service completion:* The charging process is completed, and the vehicle is ready to go. The service provider may confirm the completion of the service through the app, potentially prompting the user to make a payment (if not done upfront).

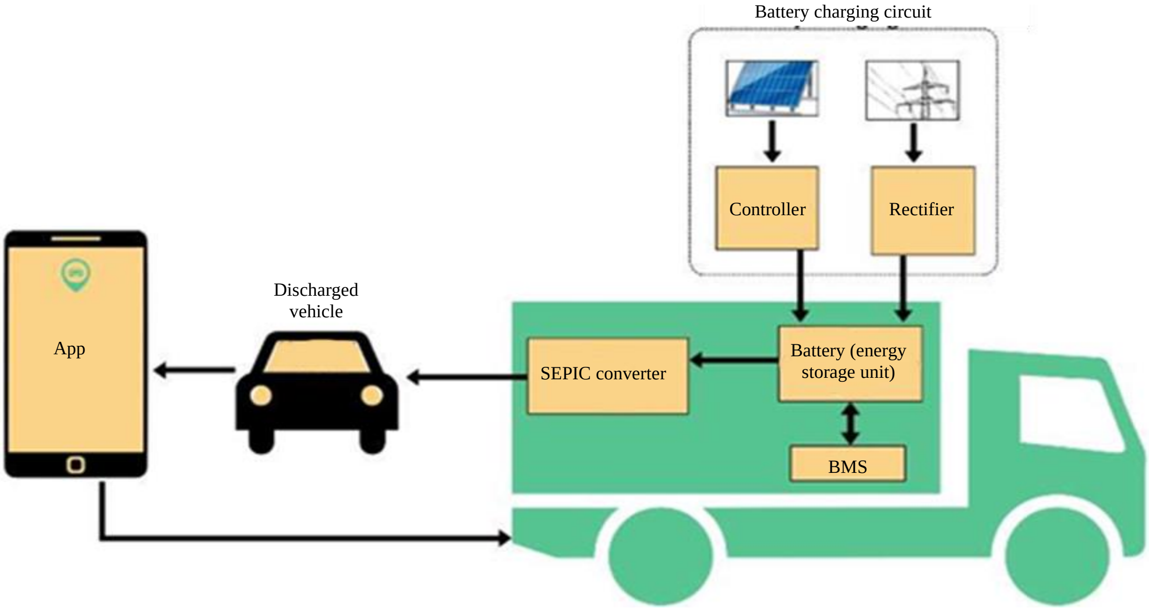

Figure 2. Workflow of the proposed system.

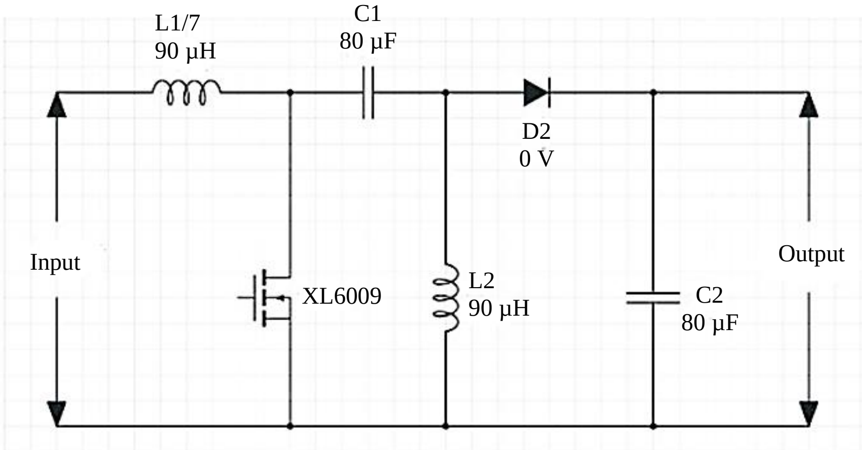

Figure 3. Circuit diagram of SEPIC converter.

Circuit of Single-Ended Primary-Inductor Converter

The SEPIC is an essential component in EV chargers because it maintains a consistent output voltage despite changes in the input voltage and hence it is useful for charging electric vehicles as shown in Figure 3. It controls the input voltage by either increasing or decreasing it or by varying the resistance to regulate the commonly used charging voltage for EV batteries. This makes it possible to use power sources such as solar panels, portable power generators, and batteries without risk. As the SEPIC provides a constant output, it also protects the EV batteries from overvoltage conditions that may lead to battery overcharging. The design is small and highly efficient; therefore, it works best with mobile chargers that have limited space and power availability. Furthermore, SEPIC devices have a wide input range that increases their functionality, allowing for convenient EV charging even in places with erratic power owing to a grid or renewable energy supply.

Design Calculation of Single-Ended Primary-Inductor Converter

The design parameters of SEPIC are discussed below.

1. Calculate duty ratio (D):

$$D = \frac{V}{V_D + V_S} = \frac{6}{6+9} = 0.4 \quad (1)$$

2. Calculate average inductance current I_{L1}:

$$I_{L1} = \frac{P_S}{V_S} = \frac{12}{9} = 1.33\ A \tag{2}$$

3. Calculate average inductance current I_{L2}:

$$I_{L2} = \frac{P_S}{V_0} = \frac{12}{6} = 2\ A \tag{3}$$

4. Calculate maximum inductance current $I_{L1\ max}$:

$$I_{L1\ max} = I_{L1} + \frac{\Delta i_{L1}}{2} = 1.33 + \frac{0.4}{2} = 1.53\ A \tag{4}$$

5. Calculate minimum inductance current $I_{L1\ min}$:

$$I_{L1\ min} = I_{L1} - \frac{\Delta i_{L1}}{2} = 1.33 - \frac{0.4}{2} = 1.13\ A \tag{5}$$

6. Calculate maximum inductance current $I_{L2\ max}$:

$$I_{L2\ max} = I_{L2} + \frac{\Delta i_{L2}}{2} = 2 + \frac{0.4}{2} = 2.2\ A \tag{6}$$

7. Calculate minimum inductance current $I_{L2\ max}$:

$$I_{L2\ min} = I_{L2} - \frac{\Delta i_{L2}}{2} = 2 - \frac{0.4}{2} = 1.8\ A \tag{7}$$

8. Calculate inductance L_1:

$$L_1 = \frac{V_S D}{f \Delta i_{L1}} = \frac{(9)(0.4)}{(100000)(0.4)} = 90\ \mu H \tag{8}$$

9. Calculate inductance L_2:

$$L_2 = \frac{V_S D}{f \Delta i_{L2}} = \frac{(9)(0.4)}{(100000)(0.4)} = 90\ \mu H \tag{9}$$

10. Calculate load resistance (R):

$$R = \frac{V_0^2}{P} = \frac{(6)^2}{12} = 3\Omega \tag{10}$$

11. Calculate capacitance C_1:

$$C_1 \frac{V_o D}{R f \Delta v_{C1}} = \frac{(6)(0.4)}{(3)(100000)(0.1)} = 80\mu F \tag{11}$$

12. Calculate capacitance C_2:

$$C_2 \frac{V_o D}{R f \Delta v_{C2}} = \frac{(6)(0.4)}{(3)(100000)(0.1)} = 80\mu F \tag{12}$$

RESULTS

The development of a mobile EV charger powered by renewable energy sources, as shown in Figure 4, is a highly efficient and portable solution that primarily increases the efficiency of charging electric vehicles while lowering their environmental impacts. A portable fast charging circuit was developed using a SEPIC converter, as shown in Figure 5. The SEPIC converter was designed using the design calculation shown in Figure 5 and was also simulated.

The simulation results are shown in Figures 6 and 7, respectively. The voltages were kept constant by increasing the output current, which enabled fast charging. Created a web application for EV owners to book charging services, as shown in Figures 8 and 9, track charging status, and make payments. Integrated real-time location tracking using GPS and Google Maps. A user-friendly interface was designed for easy navigation and management of charging sessions.

Figure 4. Prototype of the proposed system.

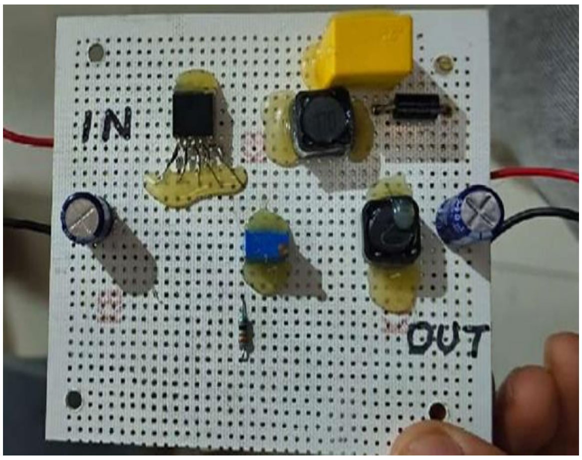

Figure 5. SEPIC converter.

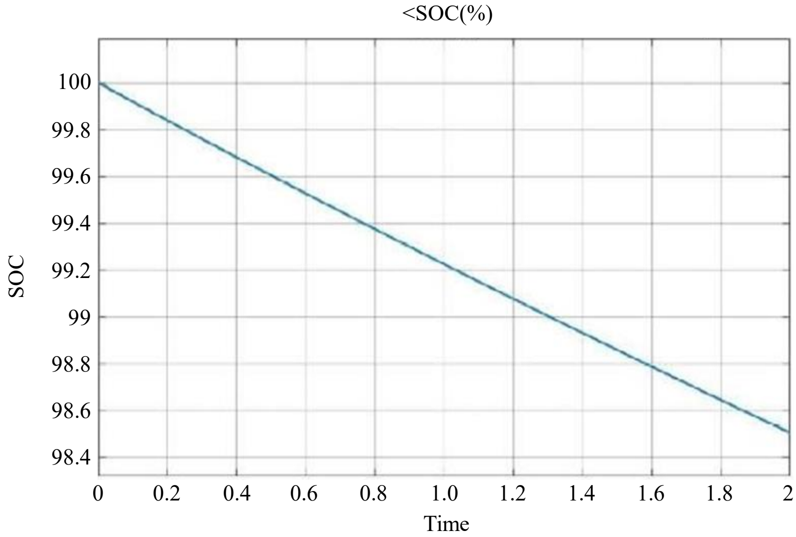

Figure 6. Mobile charger state of charge while charging EV battery.

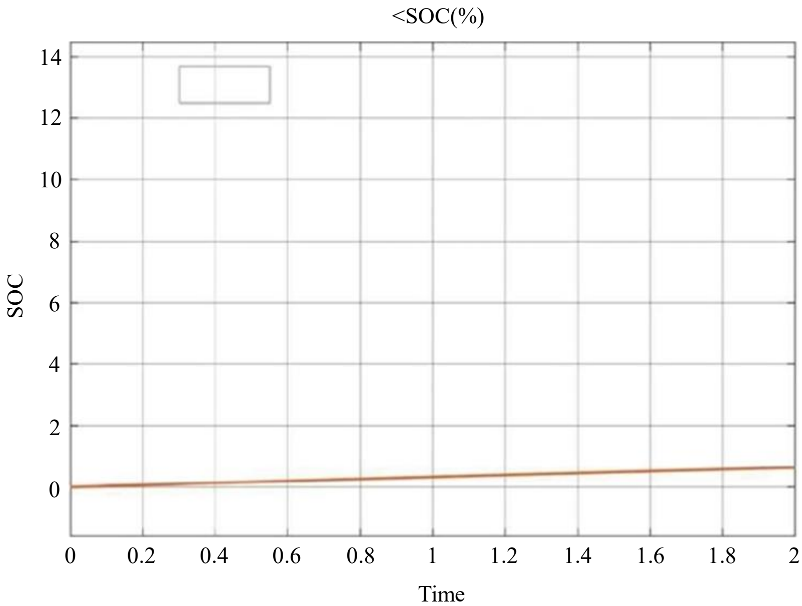

Figure 7. State of charge of EV battery while getting charged by mobile charger.

Figure 8. EV charging system App login page.

Figure 9. Request for charging the EV battery.

CONCLUSION

The increasing demand for electric vehicles necessitates the development of efficient and innovative charging solutions. Mobile EV charging systems, enhanced by fast charging technology and app-based integration, represent a promising advancement in the EV infrastructure. These systems address critical challenges, such as range anxiety and limited charging accessibility, by incorporating features such as real-time location tracking, on-demand booking, and renewable energy utilization. The findings indicate that mobile charging solutions can significantly boost EV adoption rates and support urban mobility through flexibility and convenience. However, continued advancements in app functionality and charging technologies are essential for these systems to operate efficiently and to become a seamless part of the larger EV ecosystem. With these improvements, mobile EV charging systems have the potential to transform how electric vehicles are charging, fostering a more sustainable and accessible future.

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