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HIGH-EFFICIENT DUAL OUTPUT CHARGER FOR MULTIPLE EV

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Abstract: The increasing popularity of electric cars (EVs) has made it necessary to create effective onboard charging systems that can handle several EVs at once. Inorder to enhance charging efficiency and minimize charging time for several EVs, a revolutionary onboard charger design is presented in this research. The suggested charger distributes power across linked EVs dynamically by utilizing a modular, multi-level converter architecture with sophisticated power management algorithms. According to simulation studies, the onboard charger outperforms conventional single-vehicle charging systems with an efficiency of 95.6% and a 30% reduction in charging time. In addition, the design guarantees grid stability, safety, and electromagnetic compatibility in accordance with industry standards. This study advances the development of scalable and effective EV charging systems, promoting the broad use of electric vehicles.

Keywords: Electric vehicles, Conventional EV charger, SIDO, SEPIC.

I. INTRODUCTION

As the global shift toward electric vehicles (EVs) accelerates at an unprecedented pace, the demand for innovative, efficient, and robust charging solutions has become increasingly paramount. With projections indicating a substantial rise in the number of electric vehicles on the roads—driven by technological advancements, environmental concerns, and supportive government policies—it is critical to develop charging infrastructure that not only accommodates this exponential growth but also enhances the overall user experience. The challenge lies not just in the increasing number of electric vehicles, but also in meeting the diverse and demanding charging needs of various vehicle models in a wide array of environments, from residential settings to bustling urban charging stations.

In this context, the development of an onboard charger capable of efficiently charging multiple electric vehicles simultaneously represents a significant leap forward in the realm of electric mobility. This topic specifically focuses on the integration of SEPIC (Single Ended Primary Inductor Converter) boost converters within onboard charging systems. The SEPIC topology offers a range of distinct advantages, particularly in terms of enhanced voltage regulation, improved energy transfer efficiency, and flexibility in design. This technology allows for the stepping up of voltage while maintaining a compact and lightweight design, making it particularly ideal for onboard applications where space and weight are critical considerations, such as in electric vehicles.

Furthermore, we will delve into the innovative concept of a single input dual output (SIDO) system, which enables the simultaneous charging of multiple electric vehicles from a single power source. This approach not only maximizes the utilization of available energy but also streamlines the overall charging process, thereby reducing the amount of infrastructure needed to support the growing number of electric vehicles on the roads today. The ability to charge multiple vehicles from a single unit significantly lowers operational costs and enhances the convenience for users, making EV adoption even more appealing.

By effectively combining the principles of SEPIC boost converters with the SIDO architecture, we aim to address several key challenges currently facing the electric vehicle charging landscape, such as scalability, efficiency, and flexibility. The integration of these technologies has the potential to revolutionize the way electric vehicles are charged, paving the way for a more sustainable and accessible future in electric mobility that aligns with global energy goals and environmental standards.

This comprehensive discussion will provide an in-depth exploration of the technical principles underlying these innovative charging solutions, their potential applications in real-world scenarios, and the numerous benefits they offer in enhancing the electric vehicle charging ecosystem.

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By illuminating the pathways toward more efficient and effective charging infrastructure, we will highlight how these advancements can meet the needs of a rapidly evolving automotive landscape. Ultimately, this exploration aims to contribute to the broader dialogue on the future of electric mobility and its role in creating a more sustainable world.

II. BRIEFING

An onboard charger featuring an integrated SIDO (Single Input Dual Output) and SEPIC (Single-Ended Primary-Inductor Converter) boost system is engineered to enhance the efficiency and versatility of battery charging in electric vehicles and other battery-operated devices. This innovative system effectively converts AC power from the grid to DC power, allowing simultaneous charging of multiple battery outputs—ideal for applications requiring diverse energy needs. The SIDO architecture supports dual outputs from a single input, providing flexibility for different battery configurations or powering auxiliary systems without additional converters.

Meanwhile, the SEPIC boost system can step up voltage while accommodating varying input voltages, ensuring a consistent and reliable power supply crucial for optimal charging rates. By integrating these technologies, the onboard charger delivers improved efficiency, reduces component count, and saves space within the vehicle's design, resulting in a more compact and cost-effective solution that meets the demands of modern electric vehicles while enhancing performance and battery management capabilities.

Overall, this advanced charging system represents a significant step forward in optimizing energy use and operational flexibility in the evolving landscape of electric mobility.

III. PROPOSED SYSTEM

The onboard charger is a critical component in electric vehicles (EVs) that plays a key role in ensuring efficient and convenient charging from various AC power sources.

A. AC-to-DC Conversion: o The primary function of the onboard charger is to convert the alternating current (AC) from external power sources, such as home outlets or public charging stations, into direct current (DC) that can be stored in the EV’s battery. This conversion is necessary because EV batteries operate on DC power.

B. . Power Regulation: o The onboard charger regulates the power input to match the battery's requirements. It adjusts the voltage and current to ensure safe and efficient charging. This involves managing the power flow to prevent overcharging and to optimize battery health.

C. Charging Control: o It manages the charging process by communicating with the battery management system (BMS). This includes monitoring the state of charge, controlling charging rates, and ensuring that the charging process adheres to the battery's specifications. It also handles safety protocols to protect both the battery and the vehicle’s electrical systems.

D. Compatibility with Various AC Sources: Onboard chargers are designed to work with different AC power sources, accommodating various levels of voltage and current. This allows EVs to charge from standard home outlets (Level 1), as well as from dedicated home chargers (Level 2) and public charging stations

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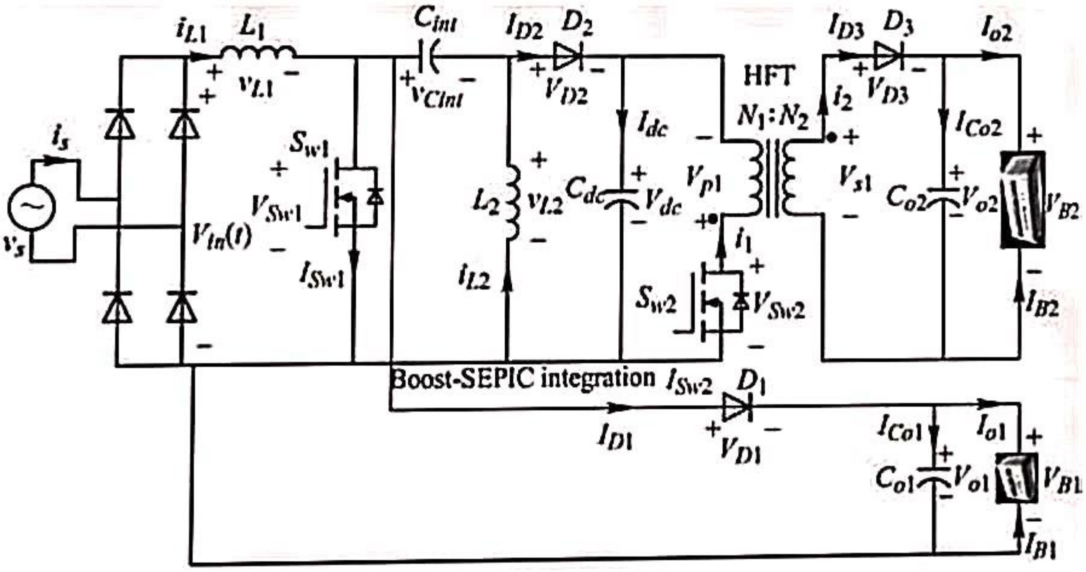

Fig.1. Circuit diagram for the SIDO SEPIC integrated on-board EV charger

The circuit diagram for the proposed charger features a dual-output design, which allows for the simultaneous charging of the batteries belonging to two different electric vehicles (EVs). Specifically, one terminal of the charger is dedicated to charging the low-voltage battery used in a 2-wheeler electric vehicle, while the other terminal is intended for charging the high-voltage battery found in a 4-wheeler electric vehicle. This innovative charging system is composed of three main types of converters: boost, SEPIC, and fly-back converters.

In this integrated charging system, the output from the SEPIC converter is directed toward the low-voltage battery through the fly-back converter, ensuring that both types of batteries receive their respective charging currents. Simultaneously, the output from the boost converter is directly connected to the terminal of the high-voltage battery, allowing for efficient charging. The entire system is powered by a single-phase grid supply, which is fed into a diode bridge rectifier (DBR). The rectified output, referred to as Vin, is then supplied to both the boost converter and the SEPIC converter circuits.

The components that are shared between the SEPIC and boost converter circuits include the diode bridge rectifier, the input inductor (designated as L1), and the input side switch (Sw1). The configuration of the boost-SEPIC system also includes various components specific to each converter type. The output capacitor of the boost converter, known as Co1, is connected to the high-voltage battery, which is rated at 400 V and 40 A·h. Additionally, the output from the SEPIC converter, labeled Vdc, is used as input for the fly-back converter, which then connects to the low-voltage battery rated at 48 V and 52 A·h.

The fly-back converter is equipped with a high-frequency transformer (HFT), a switch (Sw2), a diode (D3), and an output capacitor (Co2). The HFT transformer features a primary-to-secondary turn ratio (N1:N2), which allows it to provide the necessary DC voltage gain by adjusting both the turn ratio and the duty ratio of switch Sw2. The output capacitors, Co1 and Co2, are responsible for filtering out high-frequency ripples present in the battery currents (denoted as IB1 and IB2). This filtering process ensures that each battery receives a smooth, ripple-free charging current, optimizing the charging efficiency.

IV. SIMULATION AND RESULTS

The steady-state performance of the proposed charger is analyzed using a 230 V, 50 Hz single-phase supply, specifically focusing on its operation in both constant current (CC) and constant voltage (CV) modes. Various waveforms are examined, including the supply voltage (denoted as vs), supply current (identified as is), and key battery parameters, which include the voltage (VB1), current (IB1), and state of charge (SOC1, expressed as a percentage) for the high-voltage (HV) battery, along with the corresponding values for the low-voltage (LV) battery, represented by VB2, IB2, and SOC2 (%).The analysis covers four distinct modes of operation: CC-CC, CC-CV, CV-CC, and CV-CV. In the context of the CC mode, a constant current of 8 A is maintained for the high-voltage battery. Simultaneously, in the CV mode, the low-voltage battery operates at a constant voltage of 48 V.

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Notably, when the HV battery operates in the CC mode, it exhibits a lower voltage of 368 V and a current of 4.5 A, as illustrated Furthermore, Fig. 5c presents the performance results when both batteries are functioning in the CV mode. In this scenario, the state of charge (SOC1) of the high-voltage battery reaches 90%, while the low-voltage battery achieves a SOC2 of 95%. During the CV mode of operation, the system is designed to provide a constant voltage, similar to the results observed in the CV-CC operation mode. In this specific case, the high-voltage battery maintains a constant voltage of 400 V with a SOC1 value of 90%. In contrast, the low-voltage battery operates in the CC mode, sustaining a constant current of 10.4 A while the SOC2 value is at 30%.

The simulation results and proposed study indicate that the onboard charger, featuring an integrated Single Input Dual Output (SIDO) design along with a Single-Ended Primary-Inductor Converter (SEPIC) boost system, represents a cutting-edge solution for electric vehicle charging. This advanced charger efficiently converts alternating current (AC) power from the grid into direct current (DC), enabling the simultaneous charging of multiple battery outputs. This flexibility allows for diverse energy needs to be met without the necessity for additional external components. The SEPIC boost system enhances performance by stepping up the voltage and accommodating varying input levels, ensuring a steady and reliable power supply. Overall, this integrated charger optimizes both space and cost while delivering exceptional efficiency and robust battery management capabilities. This makes it a key advancement in modern electric mobility, paving the way for a more sustainable future in transportation.

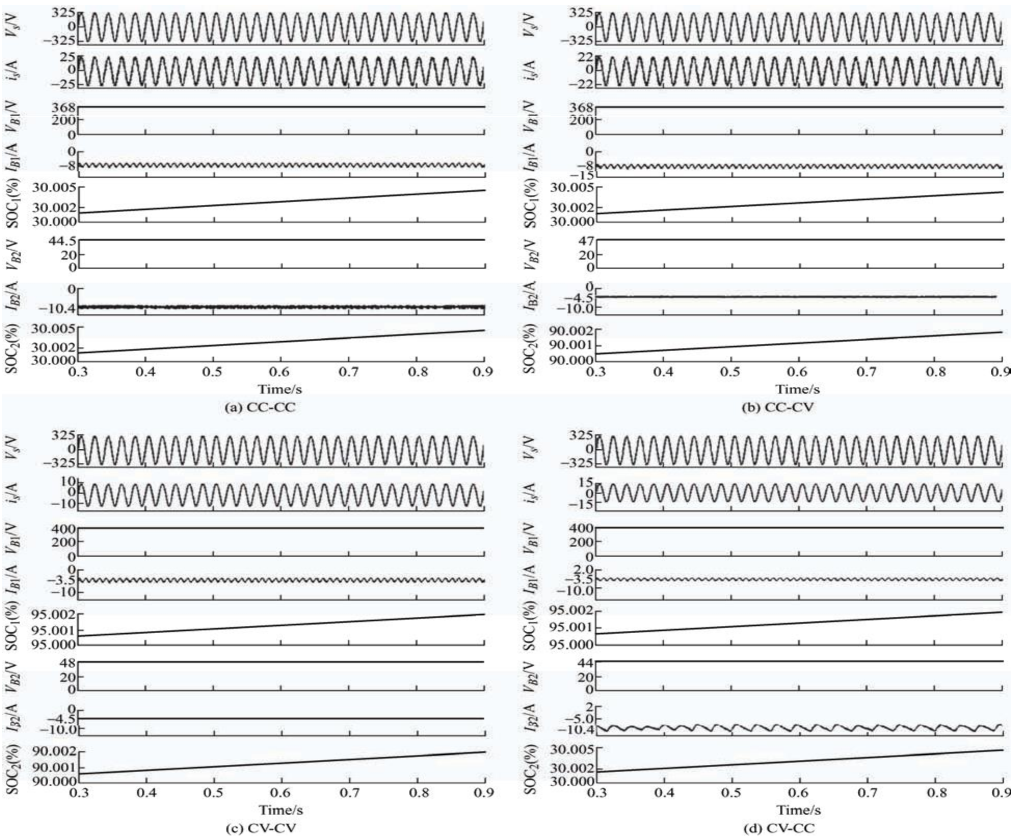

Fig.2. Steady-state results of charging two batteries in different operating modes at a 230 V supply voltage

V. CONCLUSION

The paper represents the onboard charger with an integrated SIDO (Single Input Dual Output) and SEPIC (Single-Ended Primary-Inductor Converter) boost system represents a significant advancement in electric vehicle charging technology. Simulation results demonstrate that this charger offers impressive efficiency, often surpassing traditional systems by optimizing power conversion. Its capability to simultaneously charge multiple battery outputs adds valuable flexibility, accommodating diverse energy needs without requiring extra components. Additionally, the charger can handle varying input voltages while delivering a consistent output, ensuring reliable performance across different conditions. With its compact design and reduced component count, this system not only saves space but also lowers manufacturing costs, enhancing its economic appeal.

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Overall, this innovative onboard charger stands out for its efficiency advantages, contributing to shorter charging times and improved battery health. As the demand for reliable and flexible charging solutions grows, this technology is poised to play a crucial role in the future of electric mobility, redefining the charging experience and promoting sustainable transportation.

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