



A High-Efficiency LLC Resonant Converter for EV Charging Stations with Wide Voltage Range and Reduced Voltage Stress

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ABSTRACT: Electric vehicle (EV) charging systems require high efficiency, wide output voltage range, and reduced component stress to support diverse battery technologies. Conventional LLC resonant converters maintain high efficiency only near a narrow operating point and experience increased voltage stress when subjected to wide variations in battery voltage. To overcome these limitations, this project proposes a Reconfigurable LLC Resonant Converter suitable for DC-connected EV charging stations, designed and validated using MATLAB/Simulink. The converter architecture enables dynamic reconfiguration of the resonant tank parameters.

1. Introduction

The rapid global transition toward sustainable transportation has driven an unprecedented increase in the adoption of electric vehicles (EVs). As EV penetration continues to rise, the need for efficient, reliable, and flexible charging infrastructure has become a critical priority. Modern EV charging stations must be capable of delivering high power with exceptional efficiency while ensuring compatibility with a wide variety of battery chemistries and voltage levels. In particular, DC fast-charging stations have gained significant prominence due to their ability to drastically reduce the charging duration compared to traditional AC chargers. However, designing a power conversion system that can handle wide voltage variations, maintain stable operation, and minimize component stress remains a major engineering challenge.

2. Recent Works

The existing EV charging systems predominantly rely on conventional fixed-topology isolated DC–DC converters such as the standard LLC resonant converter, phase-shift full-bridge (PSFB)

converter, and dual-active-bridge (DAB) converter. Among these, the traditional LLC resonant converter is the most widely used due to its inherent soft-switching capability, reduced switching losses, and high power-density characteristics. With fixed resonant parameters, and their performance is optimized only around a narrow operating point.

3. Proposed Work Explanation

The working principle of the proposed Reconfigurable LLC Resonant Converter is based on achieving efficient DC–DC power transfer through soft-switching, dynamic resonant control, and intelligent reconfiguration to support a wide voltage range required in EV charging applications. The converter primarily consists of a full-bridge inverter, a reconfigurable LLC resonant tank, a high-frequency transformer with adjustable or multi-tap secondary, and a rectifier followed by an output filter. The input DC voltage is first converted into high-frequency AC through the inverter

3.1 Circuit Diagram

Device stress analysis indicates substantially reduced RMS current and peak voltage on MOSFETs, enabling the use of smaller, cost-effective devices and improving reliability. Additionally, maintaining consistent soft-switching eliminates switching losses, allowing higher switching frequencies, which in turn reduces transformer and magnetic component size.

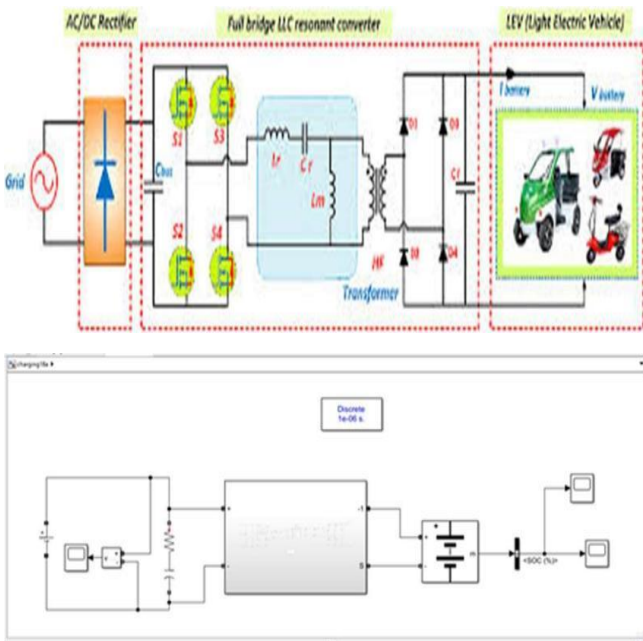


Figure 1: Overall simulation output circuit diagram

4. Results and Discussion

Through MATLAB/Simscap modeling, the system's behavior, efficiency, and stress conditions were accurately analyzed and validated, demonstrating the practicality and robustness of the proposed approach. The results confirm that the reconfigurable LLC resonant converter delivers enhanced adaptability, reduced voltage stress, improved power density.



Figure 2: Input DC Voltage

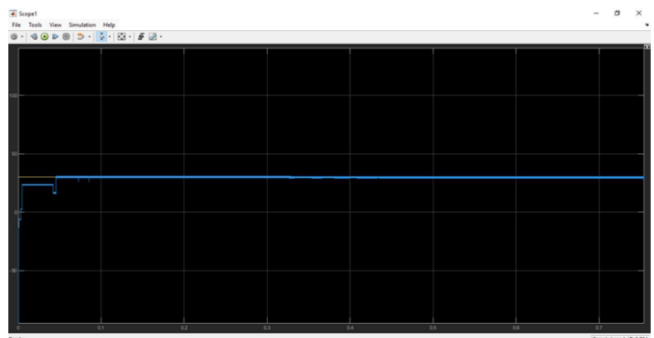


Figure 3: Dab Converter Waveform

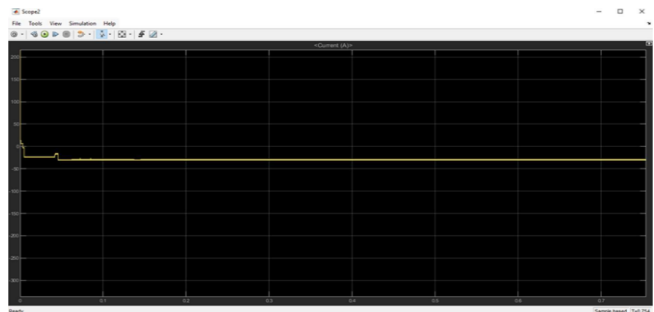


Figure 4: Set Current Actual Current

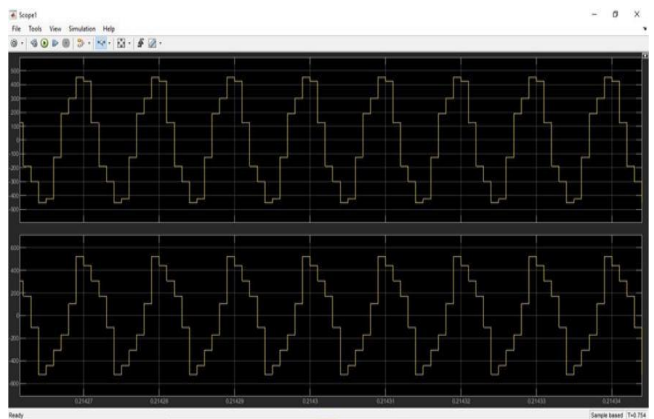


Figure 5: Battery SoC

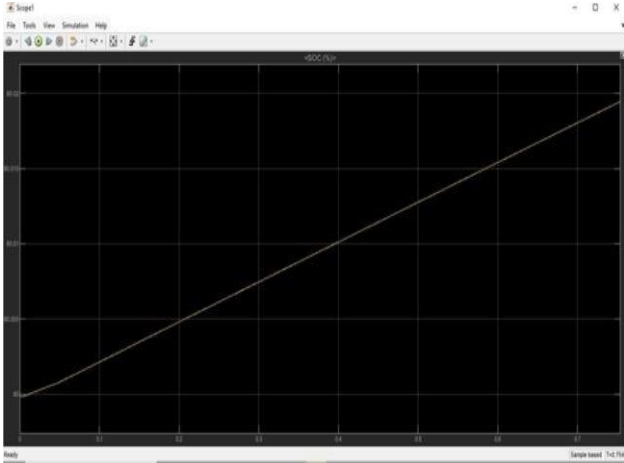


Figure 6: Battery Current

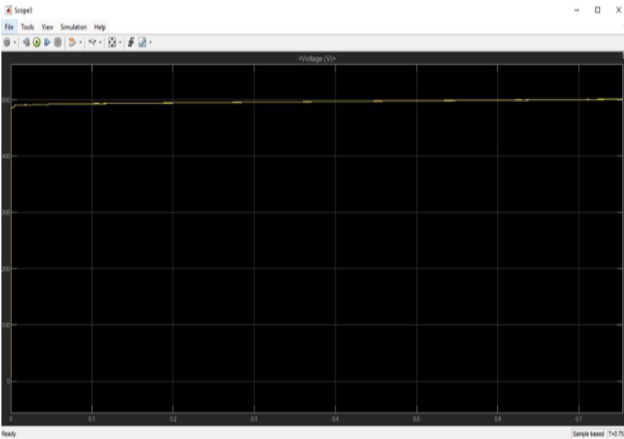


Figure 7: Battery Voltage

4.1 Preparation of Figures and Tables

4.1.1 Formatting Tables

Table 1

Title	Value	Unit
Resonant Inductor	20-40	uH
Resonant Capacitor	100-220	nF
Magnetizing Inductor	100-200	uH
Resonant Frequency	80-150	kHz
Input Voltage	800	V
Output Voltage	200-1000	V

5. Conclusion

The development of a Reconfigurable LLC Resonant Converter for Wide Voltage Range and Reduced Voltage Stress in DC-Connected EV Charging Stations successfully addresses the major limitations of conventional fixed-topology converters used in existing charging

infrastructure. By introducing dynamic resonant tank reconfiguration, optimized gain control, and intelligent PI-based feedback regulation, the proposed system achieves superior performance across the entire EV charging profile. The converter maintains soft-switching (ZVS/ZCS) under all operating modes, significantly reducing switching losses, thermal stress, and overall device degradation.

References

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