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A Systemic Review and Comparison of Non-Isolated Bi-Directional Converters

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Abstract : This paper presents a systematic classification and comparative analysis of non-isolated bi-directional DC-DC converters. The increasing demand for efficient energy conversion in diverse applications has spurred the development of various converter topologies. In this study, we categorize bi-directional converters into three distinct classes: Inverting, Non-Inverting, and Interleaved. Each category is characterized by its unique operational characteristics and benefits. Furthermore, a practical comparison is conducted by evaluating the results of simulation of each bi-directional converter. BDCs can be classified into isolated and non-isolated topologies. Non-isolated converters share a common ground between input and output, making them suitable for applications with minimal voltage change. They are easy to integrate, lightweight, and cost-effective but have limitations like limited voltage gain, switching losses, and no protection against high voltages. Isolated converters use transformers to separate input and output, offering safety benefits, high voltage gain, and noise reduction. They are larger and more costly but are essential for automotive designs where safety is crucial. The paper focuses on non-isolated systems.The paper discusses the classification of non-isolated bidirectional converters based on several criteria. Common factors used for classification include topology, voltage conversion, control strategy, power capacity, voltage range, and application. These factors serve as a foundation for categorizing converters, although the specific scheme might vary depending on contextual, application, or system-specific requirements. The paper presents a three-category classification for non-isolated bi-directional DC-DC converters: inverting, non-inverting, and interleaved. In the inverting category, converters produce an output voltage with reversed polarity compared to the input voltage, achieved through specific circuit configurations and control strategies. This is valuable in applications such as motor control and grid-tied solar systems. The non-inverting category consists of converters maintaining the same voltage polarity, useful in scenarios like battery equalization. Lastly, the interleaved category employs parallel converter stages to enhance power delivery and reduce current ripple. This classification framework enhances comprehension and analysis of non-isolated bi-directional DC-DC converters. The findings contribute to a deeper understanding of the trade-offs and merits associated with different converter types. As a result, this work aids researchers, practitioners, and engineers in selecting appropriate bi-directional converter solutions for specific energy conversion requirements. The proposed classification framework and experimental assessment collectively enhance the comprehension of non-isolated bi-directional DC-DC converters, fostering advancements in efficient power management and utilization.The simulation process involves the utilization of PSIM to model and simulate non-isolated bi-directional converter from both inverted and non-inverted category. The aim is to conduct a comprehensive comparative analysis of these converters, considering key performance indicators such as rise time, efficiency, ripple factor, and maximum error. This systematic evaluation provides valuable insights into the dynamic response, energy efficiency, output stability, and overall precision of the converters. The results of this comparison facilitate informed decision-making and potential optimizations, ensuring that the chosen converter configuration aligns effectively with the designated operational criteria and performance goals.

Keywords : bi-directional, DC-DC converter, non-isolated, energy conversion
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