# A High-Efficiency Modular Bidirectional DC–DC Converter for Next-Generation Electric Vehicles and Renewable Energy Integration

## Abstract

The increasing penetration of electric vehicles (EVs) and distributed renewable energy sources requires efficient, compact, and flexible power conversion systems. Existing bidirectional DC–DC converters used in EV chargers and battery–renewable interfaces often suffer from high switching losses, poor partial-load efficiency, and limited modularity, making them unsuitable for emerging applications such as Vehicle-to-Home (V2H) and Vehicle-to-Grid (V2G). This research proposes a high-efficiency modular bidirectional DC–DC converter that achieves improved performance using a simplified topology and adaptive control strategy. The proposed converter aims to enhance partial-load efficiency, ensure smooth bidirectional power flow, and enable direct integration of renewable sources with EV batteries. Simulation and prototype validation (1–2 kW range) will be conducted to demonstrate the converter's viability for next-generation EV charging and renewable-integrated energy systems.

## Problem Statement

Electric vehicles and renewable energy systems require power converters that are efficient, compact, cost-effective, and capable of reliable bidirectional power flow. However, current bidirectional DC–DC converter topologies face challenges such as high switching losses, reduced efficiency at partial loads, complex control requirements, and poor scalability for higher power levels. These limitations hinder the widespread adoption of V2H/V2G functionalities and seamless integration of renewable sources with EV batteries. Therefore, there is a need for a simple, modular, and high-efficiency bidirectional DC–DC converter that addresses these gaps and supports emerging EV–renewable hybrid applications.