No.: INTL15

Works: Ultrahigh Efficiency Bidirectional DC-DC Converter for Energy Storage and Super Charger Applications

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ITEM	DESCRIPTION
Introduction of Team	Two universities form the team with Virginia Tech Future Energy Electronics Center (VT-FEEC) leading the effort of hardware development while National Yang Ming Chiao Tung University students assisting device and prototype testing. In 2016 Google Little Box Challenge among 2000+ international teams including General Electric and Schneider Electric, VT-FEEC was the Top-3 winner and the only winner from academia and US-Taiwan combination.
Creation Motive (Problem-solving and technical value	Currently the battery charger efficiency of commercial product is <95%, which needs to be significantly improved to help expedite the CO2 reduction. Recently with wide bandgap devices available and the battery voltage level moving up to 1 kV and above, it is possible to design a battery charging system with round-trip efficiency higher than 99.5.
Research Process	There are two major loss components in a power conversion system: switching device and magnetic component. Our approach is to eliminate the switching loss by a smart computation to eliminate the switching loss under multiple device or converter paralleled condition and to move up the switching frequency to reduce the magnetic component size and loss. The switching method is called “synchronous conduction mode” (SCM) or transition mode (TM), which produces a triangular current that contains a negative portion to produce sufficient energy to discharge the semiconductor junction capacitance during switching to eliminate the switching loss.
Brief of Work (Creativity/Technical content and feasibility)	The proposed system consists of (1) energy sources including renewable energy source and (2) a common DC bus with kilo-volt level, and (3) a bidirectional DC-DC converter. The key development here is the “ultrahigh efficiency” DC-DC converter, which is now widely used in energy storage and EV super chargers. The input is 1 kV, and the output is a battery with 800-V nominal. The project goal is to increase the efficiency while reducing the size and cost. The resulting peak efficiency occurs under 1kV/15A full-load condition, in which the measured efficiency is 99.821%. From 600V to 1kV, the converter runs in constant power mode with output of 15 kW. Below 600V, the converter runs in constant current mode with a current of 25A. from 250V to 1kV, the efficiency maintains 99% and higher. The first aspect of energy saving impact area is in energy storage applications. Using US Energy Information Agency (EIA) data, the annual green energy generation is 9000TWh in 2022. Assuming 10% of this energy needs to be stored, it will amount to 900 TWh. As an average, each 500-MW coal-fire power plant produces 3-TWh electricity per year, the use of our ultrahigh efficiency bidirectional DC-DC converter will help save at least 160 coal-fire plants. The second aspect of energy saving area is in EV super charging applications. According to International Energy Agency (IEA), the number of fast charger stations reached 2.7 million at the end of 2022 with 5% growth annually. Assume each charging station is rated 100 kW and operate 10 hours a day in average. The global energy usage will be 2.7 TWh per day, and the annual energy saving will be 49 TWh. With the use of our ultrahigh efficiency DC-DC converter, the amount of coal-fire power plant elimination will be 16. A total of 176 coal-fire plants will be eliminated with our 99.8% bidirectional power conversion efficiency and loss reduction.