A High Efficiency, Large Voltage Range Bidirectional DC-DC Converter Based on Partial Power Processing and Solid State Transformer Architecture for Battery Charging Applications

Due to environmental concerns, there has been a significant increase in the electrification of transportation through electric vehicles (EVs). Consequently, there needs to be a suitable charging station for the different EVs in the market. To ensure the compatibility of EV service equipment (EVSE) with different EVs, organizations such as the Society of Automotive Engineers (SAE), the International Electrotechnical Commission (IEC), and Charge de Move (CHAdeMO) are working to standardize EV chargers and connectors. This provides a unique challenge for EV charger design, as the charger needs to have a wide range of output voltage.

This work presents a novel solution based on partial power processing and solid state transformer (SST) architecture to overcome this challenge. In this solution, each module of the SST consists of a high efficiency resonant CLLC converter operating like a dc transformer (DCX). Since DCX is designed to maintain fixed voltage ratio, there is a need for a post regulator to control the output voltage. However, having a post regulator on each module will greatly reduce the efficiency of the converter, due to increased switching and conduction losses. Hence, in this approach, only one module has a post regulator, which reduces the overall losses and reduces the number of devices required. To maintain the full voltage range on the output, an innovative control method is used where different modules of SST are bypassed or turned on depending on the voltage requirement.

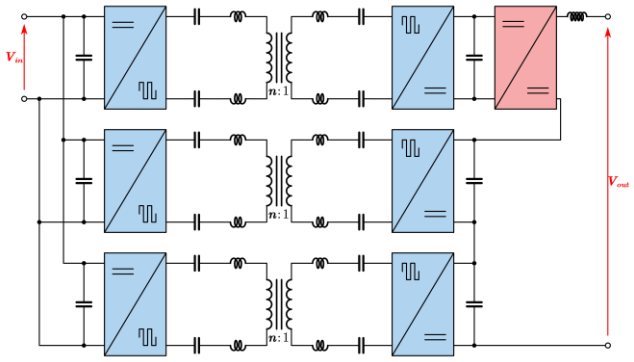

Fig. 1. System block diagram

The bypass or turn-on operations are achieved by discharging or charging the module capacitances on the high voltage (HV) side. This can be done by selectively enabling or disabling the gate pulses of each module and altering the power flow for the system. This operation has been verified by simulation and the current focus is to verify the same in the hardware.