Design and Simulation of a Single-Phase AC/DC Bidirectional Converter for Electric Vehicles V2G and G2V Applications

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In recent years, electric vehicles (EVs) have gained popularity with consumers; this technology shows great potential for conforming to the requirements of the developing Smart Grid. Currently, EV chargers are unidirectional, such that power only flows from grid-to-vehicle (G2V); research in bidirectional power transfer between EVs and the power grid seeks to expand the potential of EVs to include power flow from vehicle-to-grid (V2G). This research investigates the power electronics and control systems required for G2V/V2G bidirectional EV chargers to serve as an interface between EVs and the grid. The goal is to design, develop, and implement a prototype bidirectional EV charger. Power switches (MOSFET/IGBT) are considered for the power electronics, a PID (proportional-integrator-derivative) controller and PWM (Pulse Width Modulation) techniques utilized for the control system. Before prototype development, the circuitry is simulated on MATLAB/Simulink. Current simulations of the DC-DC Buck-Boost converter successfully demonstrated bidirectional power flow between two DC voltage sources. The next step is to simulate bidirectionality between AC and DC sources by replacing one of the DC voltage sources with an AC voltage source and developing a bidirectional AC/DC converter. Data provided by the simulation and prototype will contribute to further study of bidirectional power flow for EVs. Bidirectional chargers can benefit EV owners as well as the grid. When connected to the grid, G2V mode serves to fully charge an EV, once fully charged the EV charger automatically switches to V2G mode. In V2G mode, some power extracted from the EV's battery may regulate the power grid during normal conditions by methods of load leveling, frequency regulation, voltage regulation, etc. In cases of power outages, the V2G functionality may serve as

a lifeline to support critical loads such as hospitals, senior homes, and residences, thus signifying the importance of this research.