A smart power ASIC (SPIC) for a distributed power system

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Abstract

We describe the design and implementation and discrete validation of a high-voltage BCD-technology-based smart power integrated circuit (SPIC) design, which is an ‘one-chip solution’ to control, drive, and protect a two-stage distributed power system (DPS). As such, the proposed SPIC achieves higher power density, reduced design-cycle time, and enhanced system reliability. DPS comprises a front-end ac/dc single-switch power factor-correction (PFC) converter, which is cascaded with a back-end dc/dc four-switch full-bridge zero-voltage switching (FBZVS) converter. The current- and the voltage-mode controllers for the PFC and the FBZVS converters, respectively, are integrated into the SPIC. The SPIC can ‘directly’ fire the two high-side and three low-side devices in the power system. A combination of bootstrap and charge-pump techniques is used to power the gate drive circuits for the high-side power devices; hence, the duty cycle for a high-side power device is 100% and independent of the turn-on time of the low-side power device in the same leg of the FBZVS converter. Additionally, a more reliable two-stage fault protection scheme is implemented in the SPIC including protection features such as under-voltage lockout, over-current protection, adaptive shoot-through protection, and soft-start capability. This paper illustrates several key experimental results obtained by controlling DPS using the discrete SPIC to validate the functionalities of the latter and the satisfactory performance of the overall system.

Keywords: Smart power integrated circuit, power factor correction, dc/dc converter, full bridge, zero-voltage switching, and distributed power system.