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A Modularized High Power Solid-State Switch for Pulsed Electric Fields (PEF) Applications

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Pulsed electric fields (PEF) technology is an innovative non-thermal pasteurization method by using the high electric field (more than 20 kV/cm) and short duration (ns to ms) pulses to inactivate microorganisms and enzymes with only a small increase in temperature. In accordance with the aforementioned working principle of PEF application, a repetitive high power solid-state switch with high voltage and current capacity is designed and implemented, based on series and parallel connection of discrete 1200V IGBTs. The proposed switch is composed of ten IGBT stacks formed with four series-connected IGBT function units, and each unit is made up of one gate driver and four parallel-connected IGBTs. On this basis, a digital signal processor (DSP) is utilized as the control unit of the system, which monitors the state of the switch and produces the gate driving signal. This paper investigates the causes and solutions of unequal sharing of voltage and current happened in IGBT series-parallel topology. A snubber circuit with optimized parameters is suggested to ensure the synchronization of IGBTs switching. To solve the problem of unbalanced sharing current in the parallel circuit, all of devices on IGBT stacks are arranged annularly and placed on an integrated circular printed circuit board (PCB) to diminish the parasitic effect, and IGBTs with close electrical characteristics are screened to use for reducing the difference sharing of current among parallel branches. Furthermore, a protection circuit has been developed to shut down the IGBT stacks when the load is shorted. Applying the switch to the high-voltage pulse generator for PEF processing, the test shows that the generator could produce high voltage square wave pulses with steep edge stably, which achieves the pilot-scale processing capacity. And the protection circuit responds effectively to prevent the switch damaged when short circuit occurs.

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