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Active gate control for multiple series connected SiC MOSFETs

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Silicon (Si) is the most widely used in power electronic devices. However, due to its limitations regarding blocking voltage and switching frequency, wide band gap (WBG) materials have been under extensive research. Especially, Silicon carbide (SiC) device is expected to replace the Si device in many applications. However, current commercial SiC device ratings still has much room for improvement. In order to achieve high voltage and power, series connection of SiC devices can be considered. A major challenge in connecting devices in series is the voltage unbalance issue among the devices. To balance the voltages, a simple RC snubber circuit can be used [1]. The main issue with the snubber circuit is that the total power loss is higher than without snubber circuit. The active gate drive (AGD) control is another promising alternative. It controls the gate current to adjust dv/dt and therefore can achieve transient voltage balancing. The existing gate current control method for series SiC MOSFETs is limited to up to two devices [2]. To connect multiple SiC devices in series, a snubber circuit is needed to be used with the gate drive [3]. Considering a drawback of using snubber circuit, a AGD control method for multiple series connected devices without snubber circuit is therefore proposed. In this paper, an AGD control for multiple series connected SiC MOSFETs will be presented. It is a closed loop control method and can deal with more than two series connected devices without snubber circuit. The gate current of each device will be controlled by monitoring the unbalanced voltages. The simulation results of the proposed circuit and controller will be presented in the full paper.

[1] K. Vechalapu and S. Bhattacharya, “Performance comparison of 10 kV-15 kV high voltage SiC modules and high voltage switch using series connected 1.7 kV LV SiC MOSFET devices,” 2016 IEEE Energy Conversion Congress and Exposition (ECCE), Milwaukee, WI, 2016, pp. 1-8.
[2] Z. Zhang, F. Wang, L. M. Tolbert and B. J. Blalock, “Active Gate Driver for Crosstalk Suppression of SiC Devices in a Phase-Leg Configuration,” in IEEE Transactions on Power Electronics, vol. 29, no. 4, pp. 1986-1997, April 2014.
[3] S. Hazra, K. Vechalapu, S. Madhusoodhanan, S. Bhattacharya and K. Hatua, “Gate driver design considerations for silicon carbide MOSFETs including series connected devices,” 2017 IEEE Energy Conversion Congress and Exposition (ECCE), Cincinnati, OH, 2017, pp. 1402-1409.

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