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A High Performance Gallium Nitride based DC Pulse Converter

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Abstract- The Gallium Nitride (GaN) based switching semiconductor devices present substantial advantages over their Silicon (Si) and Silicon Carbide (SiC) based switching devices in terms of switching speed, conduction loss, and promise for extended voltage ratings and current carrying capabilities in their future generations [1]. However, currently GaN based switching semiconductor devices are not available in high voltage and high current ratings, which could be a limiting factor in their use for high voltage and high current applications. This paper presents an approach to design and develop circuits through cascading GaN based semiconductor devices to accommodate for higher voltages, beyond the ratings of commercially available single switches.

In this paper, the GaN devices are used to design and control high voltage pulse converters. Developing DC pulse power converters, even using conventional Si and SiC based switches, requires cascading the semiconductor devices. Achieving higher voltage rating through series connection of semiconductor switches reduces the switching speed and *di/dt* while increasing the switching losses [2]. Furthermore, simultaneous switching is inevitable for series connected switches and even a small delay in switching could cause major damage to the circuit through reflecting all the bus voltage across single switch beyond its limitation.

Series connected switches are synchronously switched through either load-side voltage balancing methods or gate-side voltage balancing techniques. The load-side voltage balancing methods are classified as impedance symmetrization, clamp circuits and snubber circuits as shown in Fig. 1(a) to Fig. 1(c), respectively. The drawbacks of these configurations are increased number of components, higher cost, higher losses and reduced switching speed. The gate-side voltage balancing methods include *dv/dt*- and *di/dt*-control, active overvoltage-protection by using dynamic clamps, high precision gate driving, cascaded synchronization and time delay compensation, as shown in Fig. 1(d) [3]. The gate-side voltage balancing techniques require complicated gate drive circuits.

The GaN FETs are the most suitable switches capable of enabling extremely fast voltage slopes in DC pulse converters. In this paper, a DC pulse converter achieved by unique combination of series cascaded GaN FETs is presented, which is controlled through a unique combination of load-side voltage balancing and high precision gate driving. The modeling, simulation, design, and development of the power electronic converter is outlined to demonstrate the superior advantages of series connected 200V EPC GaN FETs in terms of efficiency, switching frequency, and number of required passive components.

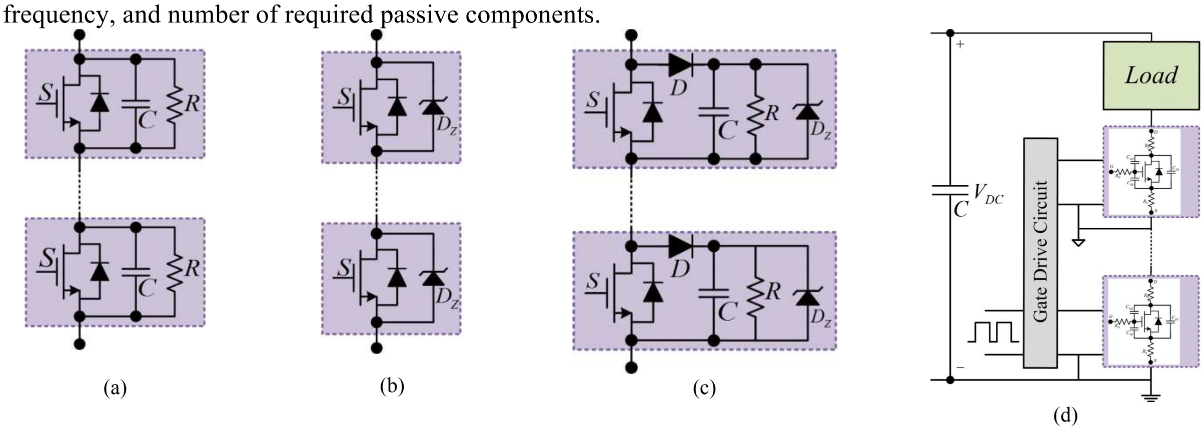

Figure 1: (a-c) Different series connected GaN FETs configuration (d) high voltage DC to pulse converter

References

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