Defense Announcement

DC/DC Converters with High Power Density and Fast Response for Pulsed Load Applications

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(Abstract/Summary)
Pulsed loads are widely being powered using solid state converters in various modern applications, such as radar, nuclear magnetic resonance imaging (NMR), light detection and ranging (Lidar), etc. Since these loads require periodic high power bursts, the power converters need to handle the following three conditions: 1) high peak to average power ratio (PAPR); 2) small duty ratios under peak power; and 3) fast pulse rise and fall times. With the additional requirement of high power density in modern space-constrained applications, these bring several challenges in the design of such 'pulsed power supplies' or PPSs.
In applications involving voltages up to 900 V, Gallium Nitride (GaN) devices are increasingly being preferred due to their advantages over Silicon Carbide (SiC) and Silicon (Si) devices. This dissertation bridges the use of GaN devices with new converter architectures and control techniques to improve the power density and response speed of PPSs.
First, design and development of a high power density 375 V input, 50 V output, two stage GaN based DC/DC converter prototype for 4 kW/800 W (peak/average) pulsed load application is discussed, along with its hardware, in this dissertation. By the benefits of lower switching loss, the first stage isolated converter can operate in a higher frequency to reduce transformer size. Higher switching frequency of 1 MHz also contributes to a high bandwidth of the second non-isolated converter stage, which improves the transient performance. A novel average current control strategy has been proposed and applied in this PPS, which reduces the input current noise at pulse repetition frequency (PRF), and, therefore, reduces the input filter size and power rating. Some practical issues (such as the failure of ZVS during light load, voltage ringing caused by GaN devices with small Coss, and the limit of DSPs' processing