As the computers are becoming more powerful and complex, power management solutions impose new challenges to high power density and high efficiency converters. In today's technology, voltage regulator module (VRM) solutions for the CPU and other major point-of-Loads (POL), such as memories and graphics, employ multi phase or single phase DC-DC buck converters. The improvement of the DC-DC converters efficiency is ultimately critical. The trend towards DC-DC converters with higher switching frequency ignites a demand to minimize MOSFET-related switching losses and in turn imposes significant challenges to power MOSFET. The latest generation of low voltage power MOSFETs, such as NexFET, is achieving very impressive performance. In parallel, however, the parasitic inductance and resistance introduced by the device package become more important as the output voltage rating of the DC-DC converter continues to decrease and the nominal current is increasing. Unfortunately, faster switching FETs usually lead to higher voltage ringing which occurs on the phase node of the buck converter and no additional measures are introduced. This voltage overshoot always induces EMI related problems and/or undesired power stress to the power switches.

In this dissertation, an alternative solution, the integrated NexFET power module is introduced to overcome the aforementioned challenges associated with the state-of-art technology and to enable next-generation converters to work in mega-hertz frequency range. The new power module uses an innovative stacked-die package technology, implements low threshold voltage power MOSFET in the low-side position, and introduces monolithically integrated components to avoid shoot-through and minimize voltage ringing at the switch node. The new generation NexFET power module fabricated with 0.35um CMOS technology demonstrates its superior high-frequency and high-current capability. In synchronous buck application, this power module achieves over 90% efficiency and low switch node ringing at high output current rating (25A) and high operation frequency (1MHz) under 12V input and 1.3V output condition. With shoot-through protection and switch node voltage ringing optimization, this new power module delivers an excellent solution for future high frequency, high current density DC-DC converters.