Tutorial #4

Pursuing the Performance Entitlement of Wide Band-Gap Semiconductors: Opportunities and Challenges

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Biography

Andrew N. Lemmon received the B.S. degree in electrical engineering from Christian Brothers University, Memphis, TN, in 2000; the M.S. degree in electrical and computer engineering from The University of Memphis in 2009; and the Ph.D. degree in electrical engineering from Mississippi State University, Starkville, MS, in 2013. From 2000 to 2010, he worked as an embedded systems design engineer at FedEx Corporation in Memphis, TN. From 2010 to 2013, he worked as a graduate research assistant in the Center for Advanced Vehicular Systems (CAVS) at Mississippi State University. He is currently an Assistant Professor at the University of Alabama, Tuscaloosa. His research interests include design of power electronics applications for wide band-gap devices, Simulation and modeling of power semiconductor devices and applications, and advanced control strategies for power electronics. Dr. Lemmon is a registered professional engineer and has been awarded four patents.

Abstract

For many years, wide band-gap (WBG) semiconductors have been forecast to revolutionize the power electronics industry. Compared to silicon devices, WBG devices offer marked improvement in terms of conduction and switching losses, thermal performance, and switching speed. As a result, these devices have been shown to yield a substantial system-level performance advantage when designed into power electronics applications such as hybrid-electric vehicles, photovoltaic inverters, and power converters for large data centers. However, the market adoption of this technology has not been as rapid as expected by analysts, even though the device maturity has continued to improve rapidly over the past several years. A partial explanation for this trend is the challenge associated with integrating wide band-gap transistors into power electronics applications in a manner which takes full advantage of their capabilities while also satisfying reliability and regulatory requirements. Optimization of power electronics applications for WBG semiconductors often encounters unexpected challenges, which are found to result largely as a side-effect of significant spectral energy in the 1-30 MHz band. In traditional power electronics applications, the energy in this “Near-RF” regime is not significant and may be safely ignored. However, WBG-based circuits must be designed in anticipation of this spectral content, particularly if the performance entitlement of the WBG devices is to be achieved while addressing other system-level requirements. The implications of the increased spectral envelope of WBG-based systems are many; and these implications demand a revolution in the techniques and tools employed by power electronics engineers for application design. During this presentation, attention will be given to cataloging these implications, describing their system impacts, and explaining known methods for mitigating the underlying cause of “Near-RF” spectral content commonly found in high-performance WBG-based applications.