Modeling & Characterization of Electro-Magnetic Interference in Power Electronics Applications Utilizing Wide Band-Gap Semiconductors

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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 device characteristics which unlock this performance advantage at the system level also reveal ancillary behaviors at the circuit level which are not as welcome. For example, the fast edge rates commonly found in WBG-based systems also lead to challenges with parasitic-induced ringing, false turn-on, half-bridge shoot-through, and the possibility of gate loop oscillation. As will be described in this presentation, the occurrence of these phenomena in WBG systems can be linked to the presence 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 WBG devices is to be achieved while addressing other system-level requirements.

During this presentation, one of the many implications of the increased spectral envelope of WBG systems will be discussed: the proliferation of Electromagnetic Interference (EMI). Although power electronics designers have been addressing EMI challenges for decades in silicon-based systems, the adoption of WBG semiconductors often reveals new challenges that are not amenable to mitigation by traditional means. The adoption of WBG semiconductors demands a revolution in the techniques and tools employed by power electronics engineers for mitigation of EMI. Over the past several years, researchers at The University of Alabama (UA) have been developing new tools to enable application designers to understand, predict, and design solutions for the high-frequency EMI behavior of WBG converters. These tools include a custom-designed EMI testbed inspired by MIL-STD-461 that can be used for characterization of WBG converters of various topologies with output power up to 100 kVA. This team has also developed and empirically validated a set of reduced-order models for common converter structures that are able to predict and explain many EMI phenomena, including common-mode behavior. During this presentation, several case studies will be provided to illustrate the operation of these tools and their utility for facilitating the design of high-performance power electronics applications.

Speaker Biography:

Andy 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.

Dr. Lemmon has 18 years of engineering experience, including 10 years as a full-time practicing engineer in industry, and 8 years as a full-time researcher in academia. Since 2013, he has served as an Assistant Professor in the department of electrical and computer engineering at The University of Alabama in Tuscaloosa. Dr. Lemmon's research group at UA is focused on (1) developing techniques for improving the realized performance of power electronics applications based on wide band-gap (WBG) semiconductors; and (2) understanding and characterizing the impact of fast-switching WBG technology as it relates to the propagation of conducted electro-magnetic interference (EMI) within common power electronics converter structures. He currently leads a multi-disciplinary team of researchers from three universities (University of Alabama, Mississippi State University, and University of Wisconsin Milwaukee) in the development of new methodologies and metrology for characterizing the conducted EMI of WBG-based power electronics systems.

To date, Dr. Lemmon has received four research grants from the Office of Naval Research, including the Young Investigator Program (YIP) award in 2018. Dr. Lemmon is a licensed professional engineer and has been awarded four issued patents.