XIII CEI ANNUAL MEETING
WIRELESS POWER TRANSFER

CEIUPM Centro de Electrónica Industrial
POLITÉCNICA "Ingeniamos el futuro" CAMPUS DE EXCELENCIA INTERNACIONAL

CEI-UPM Annual Meeting

Workshop on Power Electronics
Impact of SiC & GaN Semiconductors on Power Converters and Architectures: Challenges and opportunities

June 23rd, 2021

Time schedule is Central Europe Summer Time (UTC +2)

3:00 pm -3:40 pm	*Dr. Minjie Chen, Princeton University*
3:45 pm - 4:25 pm	*Prof. Ulrike Grossner, ETH Zurich*
4:30 pm – 5:10 pm	*Dr. Miroslav Vasic, UPM*
20 minutes Break	
5:30 pm – 6:10 pm	*Prof. Dragan Maksimovic, University of Colorado Boulder*
6:15 pm – 6:55 pm	*Dr. Juan Rivas, Stanford University*

3:00 pm -3:40 pm Dr. Minjie Chen, Princeton University

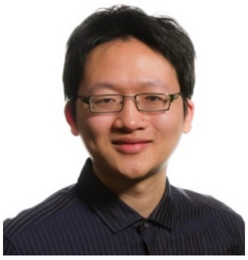
Power Architecture and Magnetics to Unlock the Potential of WBG Semiconductor Devices

Short description

Power electronics have been traditionally designed with topologies that have low component count and simple architecture.
These designs typically require substantial energy storage and bulky passive components, and are reaching their fundamental limits with decreasing performance gains. Moreover, they do not leverage the dramatic advances that have been made in semiconductor materials and integrated circuits. With the advent of wide-bandgap semiconductor materials, high-frequency magnetics, and the opportunities offered by emerging high-impact applications, sophisticated and modularized power conversion architectures are becoming extremely attractive.

This talk will present three on-going efforts about high complexity power electronics, ranging from point-of-load power converter design, differential power processing architecture, to magnetics core loss modeling based on machine learning. These three examples extend the fundamental performance boundary of power electronics from three different perspectives, and enlighten the path to much more sophisticated and modularized power electronics that will benefit a wide range of applications.

Short biography



Minjie Chen is an Assistant Professor of Electrical Engineering and Andlinger Center for Energy and the Environment at Princeton University. He leads the Princeton Power Electronics Research Lab. He received the B.S degree from Tsinghua University in 2009, and the Ph.D degree from MIT in 2015. His research interests include high frequency power electronics, advanced power electronics architectures, power magnetics, and the design of high-performance power electronics for emerging and important applications. He is a recipient of the NSF CAREER Award, two IEEE Transactions Prize Paper Awards, a COMPEL best paper award, the outstanding Ph.D. thesis award from MIT, and many other awards from the IEEE Power Electronics Society. He has published over 40 papers in journals and conferences and holds 4 issued patents.
He is the Vice Chair of PELS-TC10-Design Methodologies, an Associate Editor of the IEEE Transactions on Power Electronics and IEEE Journal of Emerging and Selected Topics in Power Electronics, the Associate Technical Program Committee Chair of ECCE 2019, and the Technical Program Committee Chair of ICDCM 2021.

3:45 pm - 4:25 pm Prof. Ulrike Grossner, ETH Zurich

Advanced Power Semiconductor Laboratory - ETH Zurich

Short description

Our research is mostly focused on the wide-bandgap semiconductor silicon carbide (SiC), which is promising to make power electronics smaller, cheaper and more efficient. We work on the full spectrum of topics concerning this semiconductor, from material characteristics via fabrication and device optimization all the way to the packages and reliability studies necessary to successfully use SiC in optimized converters.

4:30 pm – 5:10 pm Dr. Miroslav Vasic, UPM

High Frequency GaN based Conversion: Benefits and Challenges

Short description

Wide Band Gap (WBG) transistors are revolutionizing Power Electronics by making possible the design of more efficient and compact power converters, due to the lower switching and conduction losses as compared to Si devices. In this talk we will see the latest results in the field of high frequency conversion using two examples: compact dc-dc converter for an avionics application and high frequency multi-cell multi-level switching Power Amplifier. These two examples will serve us to demonstrate the possibilities of GaN and its clear advantage over Si, but, at the same time, to identify the future challenges that must be resolved in order to exploit this remarkable technology to its full extent.

Short biography

Miroslav Vasić is an associate professor at UPM. The focus of his current research are high frequency WBG converter systems, optimizations of converter topologies and AI based design. He published more than 70 papers in IEEE journals and conferences. He advised two Ph.D. thesis and holds five patents. He received the SEMIKRON Innovation Award in 2012. In 2015, he received a medal from Spanish Royal Academy of Engineering for his research trajectory as a Young Researcher. In 2016, UPM gave him the Best Young Researcher Award. He has been serving as the Vice Chair of IEEE PELS TC 10.

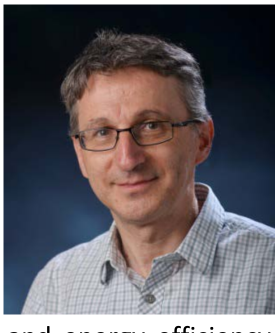
5:30 pm – 6:10 pm Prof. Dragan Maksimovic, University of Colorado at Boulder

Impact of Wide Bandgap Semiconductors and Innovations in Converter Architectures on Power Electronics Applications

Short description

Wide bandgap (SiC or GaN) power semiconductor devices offer significant advantages compared to well established silicon device technologies. In this talk, we show how the impact of advantageous device characteristics can be substantially enhanced in power electronics applications by advances in converter and system architectures, soft switching techniques, and control methods. Insights based on direct and indirect power concepts lead to efficiency improvement approaches based on converter topologies and soft-switching techniques that take advantage of wide bandgap devices. It is shown how more complex converter architectures allow for more efficient indirect power processing, leading to efficiency and power density gains, as well as application-specific system-level benefits. Challenges around complex converter configurations include more complex controls, and reliability concerns associated with increased numbers of power semiconductor components. Addressing these challenges requires innovations in modeling and control, circuit integration, and packaging techniques. Examples discussed include digitally controlled high-density, high efficiency SiC-based composite dc-dc converters for electric vehicles, modular grid-tied dc-ac systems, hybrid dc-dc converters, and very high frequency converters based on multilevel configurations and custom GaN power integrated circuits.

Short biography



Dragan Maksimovic received B.S. and M.S. degrees from the University of Belgrade in Serbia in 1984 and 1986, respectively, and his Ph.D. degree from the California Institute of Technology in 1989. Since 1992, he has been with the University of Colorado at Boulder, where he is currently a Professor and Director of the Colorado Power Electronics Center (CoPEC). He has co-authored over 300 papers, and two textbooks *Fundamentals of Power Electronics*, and *Digital Control of High-Frequency Switched-Mode Power Converters*. Prof. Maksimovic is a Fellow of the IEEE, and a recipient of the IEEE PELS Modeling and Control Technical Achievement Award. His current research interests include power electronics for renewable energy sources and energy efficiency, digital control of high-frequency switched-mode power converters, and high frequency power conversion using wide bandgap semiconductors.

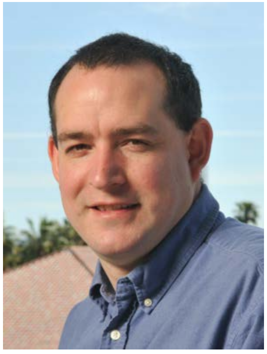
6:15 pm - 6:55 pm Dr. Juan Rivas, Stanford University

High-Frequency Power Conversion with WideBandgap Semiconductors

Short description

With the commercialization of wide-bandgap power semiconductors, multi-MHz switching frequencies are more compelling and critical to meet new applications demanding leaps in power density and efficiency. In the past, studies of these converters reported significant gaps between measured and modeled performance, often attributed to dynamic RDS,ON in GaN HEMTs. In particular, the power semiconductors – which often drive thermal constraints – dissipated much more power than expected, rendering designs based on simulated values unusable. In soft-switched converters, which dominate at MHz frequencies, the semiconductor's output capacitor is resonantly charged and discharged once per switching cycle. Recently, multiple papers have found significant losses from this process in silicon and wide-bandgap devices, explaining the unexpected power dissipation. With these losses known, the MHz-frequency design space can be reopened – if designers are careful about semiconductor selection. In this talk, I will discuss how to select the right device across material (GaN, SiC, or Si), device technology (superjunction or trench), size (lower RDS,ON is not always better), and, in some cases, manufacturer. Further, I will show how this selection drives thermal design, input voltage selection, and novel circuit topologies in a variety of high-performance demonstrations from 6.78 MHz all the way to 40.68 MHz.

Short biography



Juan Rivas is an Associate Professor at Stanford's Electrical Engineering department. Before, he served as an Assistant Professor at the University of Michigan and worked for GE Global Research in the high-frequency power electronics group. He has extensive experience in the design of dc-dc power converters working at MHz frequencies. He has published peer-reviewed work on power converters reaching up to 100 MHz using Si and WBG devices. He obtained his Masters (2003) and a doctoral degree from MIT (2006). He received his undergraduate degree from the Monterrey Institute of Technology, Mexico city campus in 1998. His research interests include power electronics, resonant converters, resonant gate drive techniques, high-frequency magnetics, and finding new applications for power converters.