GRAPES
GRid-connected Advanced Power Electronic Systems

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Advanced Center
for Electrical and Electronic Engineering

UNIVERSIDAD TECNICA
FEDERICO SANTA MARIA

Exploring Science Together

1pm-5pm ~ April 12, 2022 ~ 2pm-6pm

Central Daylight Time **Webinar** **Chile Standard Time**

1:00 - 1:05pm US Central/2:00 - 2:05pm Chile: Welcome and Introduction to Webinar, Dr. Eugene Krentsel, President, *inno*VEK, LLC

1:05 - 1:20pm US Central/2:05 - 2:20pm Chile: Introduction of GRAPES, Dr. Alan Mantooth, Executive Director, GRAPES

Dr. Alan Mantooth received the B.S.E.E. and M.S.E.E. degrees from the University of Arkansas in 1985 and 1986, and the Ph.D. degree from Georgia Tech in 1990. He then joined Analogy, a startup company in Oregon. In 1998, he joined the faculty of the Department of Electrical Engineering at the University of Arkansas, Fayetteville, where he currently holds the rank of Distinguished Professor. His research interests now include analog and mixed-signal IC design & CAD, semiconductor device modeling, power electronics, power electronic packaging, and cybersecurity. Dr. Mantooth helped establish the National Center for Reliable Electric Power Transmission (NCREPT) at the UA in 2005. Professor Mantooth serves as the Executive Director both the NSF Industry/University Cooperative Research Center on GRid-connected Advanced Power Electronic Systems (GRAPES) and the Cybersecurity Center on Secure, Evolvable Energy Delivery Systems (SEEDS) funded by the U.S. Department of Energy. Dr. Mantooth holds the 21st Century Research Leadership Chair in Engineering. He currently serves as Senior Past-President for the IEEE Power Electronics Society and Editor-in-Chief of the IEEE Open Journal of Power Electronics. Dr. Mantooth is a Fellow of IEEE, a member of Tau Beta Pi, Sigma Xi, and Eta Kappa Nu, and registered professional engineer in Arkansas.

Abstract: GRAPES is a US National Science Foundation Center of Excellence that focuses on grid modernization through advanced power electronics technologies. Research projects focus on low, medium and high voltage activities with many hardware projects at the low and medium voltage levels along with system level analyses at the transmission level.

1:20 - 1:35pm US Central/2:20 - 2:35pm Chile: Introduction of AC3E, Dr. Matias Zanartu, Director, AC3E

Dr. Matias Zanartu is an Associate Professor in the Department of Electronic Engineering at Universidad Técnica Federico Santa María in Valparaíso, Chile, and Director of the Advanced Center for Electrical and Electronic Engineering from the same institution, where he also leads the biomedical engineering research and development. He received his Ph.D. and M.S. degrees in electrical and computer engineering from Purdue University, West Lafayette, USA, and his B.S. in acoustical engineering from Universidad Tecnologica Vicente Pérez Rosales, Santiago, Chile. His interests are centered on the development of digital signal processing, system modeling, and biomedical engineering tools that involve speech, hearing, and acoustics. His research efforts have revolved around developing quantitative models of human voice production and applying these physiological descriptions for the development of clinical technologies. He is Associate Editor of the IEEE Transactions on Neural Systems and Rehabilitation Engineering, member of the Technical Committee on Speech Communication Speech Communication of the Acoustical Society of America, Fulbright fellow, and IEEE senior member.

Abstract: The main description of AC3E, its purpose, organization, research lines, main R&D capabilities, and a glance at selected projects with industry and spin-offs companies that emerged from AC3E technologies.

1:35 - 1:50pm US Central/2:35 - 2:50pm Chile: Medium-Voltage Static Compensators for Distribution Systems, Dr. Juan Balda, University Professor and Head of Department, University of Arkansas at Fayetteville; Principal Investigator, GRAPES

Juan Carlos Balda (IEEE M'78 SM'94) received his B.Sc. in Electrical Engineering from the Universidad Nacional del Sur (Bahía Blanca, Argentina) in 1979, and his Ph.D. degree in Electrical Engineering from the University of Natal (Durban, South Africa) in 1986. He was first employed as a researcher and a part-time lecturer at the University of Natal until July 1987. He spent two years as a visiting Assistant Professor at Clemson University, South Carolina. He has been at the University of Arkansas at Fayetteville since July 1989 where he is currently a University Professor, Department Head, and associate director for applications of the National Center for Reliable Electric Power Transmission (NCREPT). His main research interests are Power Electronics, Electric Power Distribution Systems, Motor Drives and Electric Power Quality. He is a senior member of the IEEE, member of the Power Electronics and Power & Energy Societies, and the honor societies Eta Kappa Nu and Tau Beta Pi. He is also the chair of IEEE PELS TC5 committee and faculty advisor to the local chapter of the IEEE Power Electronics Society.

Abstract: Unbalanced currents in distribution feeders can lead to several adverse problems; for example, negative- and zero-sequence currents reaching out the power transformer, and unbalanced voltages at three-phase loads. This webinar addresses the design of a three-phase 13.8-kV médium-voltage unbalanced current static compensator (MV-UCSC) based on the flyback topology which connects directly to a 13.8-kV distribution system without step-up transformers and makes use of two SiC MOSFETs connected in series to realice the 3.3-kV switching positions required for the system 11 levels.

1:50 - 2:00pm US Central/2:50 - 3:00pm Chile: Q&A

2:00 - 2:15pm US Central/3:00 - 3:15pm Chile: Application of Model Predictive Control (MPC) in Power Electronics and Drives, Dr. Jose Rodriguez, Associate Researcher, AC3E

Dr. Jose Rodriguez is Life Fellow of IEEE, a full professor and past president of Universidad Andres Bello in Santiago, Chile. He is member of the Chilean Academy of Engineering. One of his fields of research has been the application of model predictive control in power electronics for more than 15 years. In 2015, he received the Eugene Mittelmann Award from the Industrial Electronics Society of the IEEE. From 2014 to 2021, he has been included in the list of Highly-Cited Researchers according to Web of Science.

Abstract: Model Predictive Control has emerged as an attractive and competitive technique for the control of power converters in comparison to linear control with Pulse Width Modulation. The presentation will present the fundamentals of MPC and applications such the current control of a three-phase inverter and the torque and flux control of an induction machine. The presentation will also include the challenges for the future research work.

2:15 - 2:25pm US Central/3:15 - 3:25pm Chile: Q&A

2:25 - 2:40pm US Central/3:25 - 3:40pm Chile: High Efficient All Silicon Carbide Medium Voltage DC Transformer, Dr. Yue Zhao, Associate Professor, Electrical Engineering, University of Arkansas at Fayetteville; Principal Investigator, GRAPES

Prof. Yue Zhao received his Ph.D. degree in electrical engineering from the University of Nebraska-Lincoln, Lincoln, USA, in 2014. He was an Assistant Professor in the Department of Electrical and Computer Engineering at the Virginia Commonwealth University, Richmond, USA, in 2014-2015. Since 2015, he has been with the University of Arkansas (UA), Fayetteville, USA, where he is currently an Associate Professor in the Department of Electrical Engineering. His current research interests include electric machines and drives, power electronics, and renewable energy systems. He has 4 U.S. patents granted and co-authored more than 100 papers in refereed journals and international conference proceedings. Dr. Zhao is an Associated Editor of the IEEE Transactions on Industry Applications and IEEE Open Journal of Power Electronics. He was a recipient of 2018 U.S. National Science Foundation CAREER Award, and the 2020 IEEE Industry Applications Society Andrew W. Smith Outstanding Young Member Achievement Award.

Abstract: The GRAPES data center project will be presented in this talk. The goal of the project is to develop a high efficiency single-stage all SiC medium-voltage (MV) dc transformer (DCX), which is the most critical building block in a solid-state transformer (SST). Compare to the state-of-the-art SSTs, where series connection of multiple cells on the MV ac side is usually required, in this project, 10 kV SiC MOSFET modules are utilized on the primary side to enable a single-stage DCX from 5 kV to 400 Vdc. This design concept leads to higher reliability, higher efficiency and higher power density compared to the state-of-the-art SST. When circuit topology is simplified, the design challenges are shifted to the design of the medium frequency (MF) transformer, which is the key task in this project. A Pareto-front analysis based multi-objective optimization approach for transformer design is utilized in this project to identify the optimal operating conditions of the transformer.

2:40 - 2:50pm US Central/3:40 - 3:50pm Chile: Q&A

2:50 - 3:00pm US Central/3:50 - 4:00pm Chile: BREAK

3:00 - 3:15pm US Central/4:00 - 4:15pm Chile: Multilevel converters research at AC3D: topologies, control and applications, Dr. Margarita Norambuena, Principal Investigator, AC3E

Dr. Margarita Norambuena received her B.S. and M.S. degrees in electric engineering from the Universidad Tecnica Federico Santa Maria (UTFSM) in 2013. She received a Ph.D. degree in electronics engineering from the UTFSM and the Doktoringenieur (Dr-Ing.) degree (summa cum laude) from the Technische Universitat Berlin (TUB) in 2018. In 2019 she received the award “IEEE IES Best student paper award” for her doctoral work. Dr. Norambuena serves as an Associate Editor for IEEE JESTPE.

Abstract: In recent decades, due to high extraordinary performance in medium voltage and high power applications, Multilevel Inverters (MLI) are highly used. MLI provides lower harmonic content in the output current and voltage, the low voltage stress on devices, superior waveform quality, and lesser common-mode voltage (CMV) compared to the conventional two-level inverter. This presentation will cover some of the contributions made by AC3E in multilevel inverter topologies applied to photovoltaic energy, electric vehicle charging infrastructure, and smart grid.

3:15 - 3:25pm US Central/4:15 - 4:25pm Chile: Q&A

3:25 - 3:40pm US Central/4:25 - 4:40pm Chile: Module Temperature Balancing Through Packaging Schemes and Thermal Management Design as a Means to Reliability, Dr. David Huitink, Assistant Professor, Mechanical Engineering, University of Arkansas at Fayetteville; Principal Investigator, GRAPES

Professor David Huitink joined the University of Arkansas in 2016, prior to which he spent >5 years in industry, working in microelectronics technology development and manufacturing at Intel Corporation, where he served as Quality & Reliability Engineering Program Manager for Intel's Custom Foundry Division.There, he managed the foundry customer adoption of 2.5D packaging technology in high performance FPGA processors, and directed development of advanced methods of predicting reliability of flip chip microelectronic packages, along with advancing assembly materials selection for large die and multi-chip packages. Prior to his industry experience, Dr. Huitink received his Ph.D. in Mechanical Engineering from Texas A&M University as a NSF Graduate Research Fellow, working on complex nano-scale interactions at material interfaces under chemical and mechanical influence.

Abstract: Electrified transportation has dominated recent technology trends, notably among automobiles, but also with aviation and naval markets. This has largely been coincident with advances in densification of power electronics, which is challenging conventional electronics packaging materials and architectures. With increased power density, thermal management and reliability are increasingly critical in the design of power electronic systems. Conventional heat sinks no longer can adequately dissipate heat; and higher frequency operation also intensifies electromagnetic interference. And while increased efficiency and temperature stability in wide bandgap semiconductor devices are central to future power conversion technology, packaging research will enable the promised power density with reliability. To deliver this future, integrative design for thermal, material, and electrical performance is needed. In this talk, these trends and recent integrative research efforts in power electronics enablement at University of Arkansas will be discussed, with particular emphasis on technologies aimed at delivering reliability in the context of thermal management and materials selection.

3:40 - 3:50pm US Central/4:40 - 4:50pm Chile: Q&A

3:50 - 4:05pm US Central/4:50 - 5:05pm Chile: Power converters for energy transition applications, Dr. Samir Kouro, Deputy Director and Principal Investigator, AC3E

Dr. Samir Kouro is the Director of Innovation and Technology Transfer of Universidad Tecnica Federico Santa Maria, in Chile. He is also Deputy Director of the Advanced Center of Electrical and Electronics Engineering (AC3E). Dr. Kouro ihas received three IEEE career awards for contributions made in the field of power electronics and renewable energy, four IEEE journal best papers awards, and included in The Clarivate Analytics Highly Cited Researcher List of 2018. He also has served as technical adviser in several energy related public policy councils and boards for the Chilean Government.

Abstract: Climate change is forcing a new energy transition. Power electronics plays a critical role for the large-scale penetration of renewable energy into the grid and is also an enabling technology for the electrification of fossil fuel dependent industry applications. This presentation will cover some of the contributions made by AC3E in photovoltaic energy, electric vehicle charging infrastructure and green hydrogen production.

4:05 - 4:15pm US Central/5:05 - 5:15pm Chile: Q&A

4:15 - 4:30pmUS Central/5:15 - 5:30pm Chile: Silicon Carbide Device Processing for High Temperature CMOS Integrated Circuits Using the Multi-user Silicon Carbide Fabrication Facility, Dr. Zhong Chen, Associate Professor, Electrical Engineering, University of Arkansas at Fayetteville; Principal Investigator, GRAPES

Short bio: Prof. Zhong Chen holds a doctorate in electrical engineering from North Carolina State University, a master's degree in electrical engineering from the National University of Singapore and a bachelor's degree in instrumentation science and engineering from Zhejiang University in China. Dr. Chen worked for seven years as ESD specialist in Analog Technology Development at Texas Instruments at Dallas, TX prior to joining the faculty of the University of Arkansas in 2015. He is currently Associate Professor in Department of Electrical Engineering. He was recognized as a TMG Member of Technical Staff for his contribution and leadership at Texas Instruments. Dr. Chen has 10 issued patents. He has published in various journals and conference proceedings on topics including semiconductor processing, nanofabrication, high-k materials, thin film deposition, wide bandgap devices and packaging, etc.

Abstract: The SiC device processing using the Multi-user SiC (MUSiC) Fabrication Facility will be presented. This project will lay a solid foundation for SiC integrated circuits and device fabrication to promote greater levels of integration in wide bandgap power electronic modules. The objectives of the proposed research are to develop a SiC CMOS process flow with the compatibility with XFAB's process, pilot this process with basic SiC circuitry, and develop on-chip SiC optical isolation technology and associated special fabrication steps that can be demonstrated in the pilot processing. The MUSiC facility will address and remove many of the roadblocks facing the current and future competitiveness of US research and ingenuity in SiC electronics for a broad range of devices, circuits, and applications analogous to how silicon fabrication addresses a vast array of consumer, power, and communication electronic systems.

4:30 - 4:40pm US Central/5:30 - 5:40pm Chile: Q&A

4:40 - 4:50pm US Central/5:40 - 5:50pm Chile: Wrap-Up of AC3E, Dr. Matias Zanartu

4:50 - 5:00pm US Central/5:50 - 6:00pm Chile: Wrap-Up of GRAPES, Dr. Alan Mantooth

Link to Join Webinar

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