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ECCE 2022 Tutorials Program Covers Many Timely Topics In Energy Conversion

By David Morrison, Editor, How2Power.com

After being held virtually for the past two years, the IEEE Energy Conversion Congress & Exposition (ECCE 2022) returns in-person with a full conference schedule and exhibition from October 9-13 at Huntington Place convention center in downtown Detroit, Michigan—the defacto capital of the automotive industry in North America. On Sunday, October 9, ECCE 2022 will host an expansive program of 24 tutorials on a range of topics relating to power electronics, electric machines and their applications. Among the many subjects addressed in these sessions, vehicle electrification, power grids and wide-bandgap devices are featured prominently.

The titles, names of instructors and abstracts for these tutorials are provided on the following pages. For those wanting to know more about the instructors, their bios are also provided in an appendix following the tutorial descriptions.

For possible updates on the tutorial sessions, check the Tutorials page on the ECCE conference website. For details on the cost of attending the tutorials and other sessions, or to register, see the Rates & Registration page. For info on other aspects of the ECCE 2022 conference or exhibition, see the conference home page.

If you have further questions about this year's tutorials, you may contact the ECCE 2022 tutorial chairs, Pete Wung, Xu She, and Xiaonan Lu. Their contact information may be found on the ECCE Organizing Committee page. Or email me and I will forward your inquiry.

Descriptions Of ECCE 2022's Tutorials

T1(AM): Maritime Electrification — State-of-the-Art Hybrid Power Systems for Green Marine Transport

Instructors:

- Chendan Li, Norwegian University of Science and Technology
- Mehdi Zadeh, Norwegian University of Science and Technology
- Sidun Fang, Chongqing University
- Daniel Stroe, Aalborg University
- Ahmed Abdelhakim, ABB Research Sweden

Abstract: Marine sector decarbonization is another battlefield for meeting the goal of climate action and ensuring the fulfillment of ambitions for a zero-emission society. Driven immediately from the policies such as energy efficiency and carbon intensity indicator rating system for ships initialed by The International Maritime Organization (IMO) targeting 50% reduction on the total annual GHG emissions by 2050, and carbon taxation and labeling by European Union, a series of innovations that are centered around marine transportation are emerging from both industry and the academic.

These innovations are featured by electrification through advanced power electronic based power systems with various new energy storage systems and low-emission fuels, as well as increased intelligence and efficient control strategies applied to these maritime power systems. This tutorial aims at providing the audience a compact yet comprehensive overview of the advancement of control, operation, and design of typical maritime power systems, the condition monitoring and data analysis for energy storage, as well as relevant industrial advancements. At the same time, several practical case studies will be demonstrated to deepen the understanding of how these new approaches solved the challenges of the current and emerging maritime power systems, and to guide the future analysis and design of more advanced maritime power systems.

The following modules will be covered to address five of the key topics. First, the opportunity and challenge for decarbonization of marine transportation sector will be given, the emphasis will be on the all-electric powertrain based on state-of-the-art power electronics and fed by battery system and alternative fuels.

For the shipboard electrification, the onboard power system will represent itself in the form of microgrids. To coordinate different components, a hierarchical control both in centralized and distributed ways will be introduced in the second module. A case study of onboard microgrid hierarchical control will be given, to walk the audience around how this method can be applied to the onboard power system and the latest advancement in the control and operation will be reviewed.

As the battery will be an indispensable and the costliest component for the emerging electrified shipboard power system as well as advanced ship charging solutions, how to ensure the reliable operation and extend the lifetime of the energy storage system become a hot topic. The third module will introduce aspects related to Lithium-ion battery performance, degradation, and lifetime. Furthermore, methods for battery lifetime extension and prediction will be covered.

Not limited to onboard microgrids, marine grid is a new concept which deals with the electrification of different energy networks installed in harbors, ports, ships, and various ocean platforms with the involvement of multiple energy flows, i.e., electrical power, fossil fuel, and heating/cooling power. A cross-disciplinary view on this emerging "maritime multi-energy system" will be introduced in the fourth module.

To catch up with the lasted advancement of fuel cell developments for shipboard power system, industrial expert from ABB will give a talk covering the topics not only technically but also economics on integrating the fuel cell for the marine vessels.

T2(AM): Power Semiconductors in Electrified Powertrains – Transitioning from Silicon to Wide Bandgap Devices?

Instructor:

- Andre Christmann, Infineon

Abstract: This tutorial will provide a broad overview of power semiconductors in typical automotive xEV applications such as on-board charger, dc-dc and especially the traction inverter.

The session starts with the fundamentals of the semiconductor devices like IGBT/diodes (IGBT and RC-IGBTs) as well as wide band gap solutions (SiC and GaN) used in these applications resulting in key performance differentiators and figures of merits.

The purpose of the introduction is to gain a better understanding for typical selection criteria. Therefore, the presentation will discuss pros and cons and give several trade-offs, e.g. the qualitative cost performance trade-off.

Although the focus of this tutorial is power semiconductors, the performance of a semiconductor strongly depends on the package characteristics. The characteristics of the devices can be tuned to optimize power module performance. Both the device and module performance strongly influences the inverter efficiency, which, in turn, impacts MPG rating of the vehicle. Heat losses from the devices and module thermal performance determine the semiconductor and module size and therefore the cost of the inverter.

By connecting various aspects of power device and module characteristics, the discussion leads finally to a potential market picture from the application point of view. Besides the technical content, the presentation will also give some ideas of recent and future trends and topics like chip shortage, coexistence or cost parity of WBG- and silicon-based solution will be briefly touched.

T3(PM): Practical Application of Silicon Carbide(SiC) in the E-Mobility Ecosystem

Instructors:

- Anuj Narain, Wolfspeed
- Adam Anders, Wolfspeed

Abstract: This tutorial will cover the impact that Wolfspeed's Silicon Carbide (SiC) can make on electric vehicles and associated power ecosystem. A multitude of applications from solar panels for charging infrastructure, off-board chargers, on-board chargers, dc-dc converters and drivetrain can benefit from the application of SiC. Along every step of the ecosystem, silicon carbide saves cost and space while bringing higher efficiency as compared to silicon. This session will review system and board level application of SiC in the E-Mobility ecosystemfollowed by hands on design sessions that will be conducted using online simulators as well as physical hardware demonstrators.

T4(AM):Circuit Board Layout for Wide Bandgap Power Transistors

Instructor:

Eric Persson, Infineon

Abstract: PCB layout is already challenging for power electronic circuits. But as wide-bandgap semiconductors (GaN and SiC) are increasingly adopted, their tenfold increase in switching speed compared to silicon creates even more challenges for the circuit designer. Layout problems can lead to circuit malfunction, ringing and overshoot voltage spikes, EMI problems, higher loss than expected, and even transistor failure. Application notes often have the same advice to solve these problems: "be sure to minimize all parasitic layout inductance as much as possible." But what is the best way to approach this, especially when there are multiple conflicting layout goals? It is simply not possible to eliminate all layout impedance everywhere, so how does one make the tradeoffs to optimize the PCB layout for best performance?

This seminar addresses these questions, and leads you through a process to understand where parasitic impedances really matter, understand the magnitude of parasitic impedances, evaluate layout options, and make an informed decision on how to proceed. The focus is on the primary-side power circuits, and is intended to cover the range from approximately 50 W to 5 kW.

T5(AM): Model-Based Control Design and Testing with Embedded Code Generation Using the PLECS Toolchain

Instructor:

Beat Arnet, Plexim

Abstract: The development of a power electronic system is a multidisciplinary endeavor. It includes not only the power stage design, but also the development of the controls, which are often implemented on a microcontroller (MCU). Yet few engineers are equally skilled in hardware and software design. For example, electrical engineers are usually not professional software developers by education, however, they are often assigned the task of programming embedded MCUs at work due to their knowledge of how to control a power converter and the full system requirements. Further, they have a good understanding of the MCU's on-chip peripherals such as PWM generators and ADCs.

Meanwhile, with today's short time-to-market pressures, there is little intrinsic motivation to write code that can be reused and maintained over a product's entire lifetime. As a result, the handwritten codebase often lacks modularity, clear structure and proper documentation. For these reasons, we should support electrical engineers in what they are good at, namely electronics and control design, and leave the software architecture and implementation either to experienced software developers or to a computer program that generates the code automatically. Of course, the latter option will only be desirable if it accelerates and simplifies the development process right from the start.

PLECS in conjunction with the PLECS Coder lets control engineers not only intuitively model and simulate controls for power electronics, but also easily implement them on selected MCUs. This automatic code generation workflow neither requires special software development skills nor in-depth knowledge about the MCU peripherals. The iterative development approach using a PLECS model allows a design to evolve from an initial concept to a robust implementation where the model serves both as the control algorithm's definition and documentation.

The advantages of this approach are numerous. Configuring and accessing the MCU's I/O peripherals is no longer the manual and error-prone task of setting individual bits in configuration registers. Further, the control system can be developed and verified against a plant model using offline software-in-the-loop (SIL) simulation of the generated code on the host computer. This allows the user to identify any discrepancies between the original model and its C code implementation, such as the discretization of time-continuous control blocks. Once the embedded code is on the target MCU, the user can test and debug it by observing real-time data in PLECS and interact such as by tuning setpoint parameters.

In this tutorial, participants are welcome to bring laptops for an interactive walkthrough of the PLECS code generation process. After minimal lecture material is provided for laying out the basic building blocks and GUI, attendees will build a simple closed-loop control model, generate code for it for an STM32 MCU test kit and verify its performance with an on-board power stage. Temporary PLECS licenses and MCU hardware will be distributed during the tutorial. Further, we will demonstrate practical applications including synchronous sampling for event-based execution of control tasks, multi-tasking environments for cascaded control structures, and the use of state machine charts for supervisory control purposes.

T6(PM): Power Electronics Modeling for Real-Time Simulation

Instructors:

- Giovanni De Carne, Karlsruhe Institute of Technology
- Matthew Milton, University of South Carolina
- Andrea Benigni, RWTH Aachen University

Abstract: Digital Real Time Simulators (DRTSs) are powerful tools that enable the connection between the digital and real world. Large and complex systems, such as electrical grids, can be simulated in real time, where the digital simulators can compute their model solutions with relatively small time steps (10 to 50 µs or below). These small time steps permit to interface the simulated electrical networks with real hardware, such as grid controllers or power devices, with reasonable time fidelity and response. Interfacing these simulators with external devices by means of sensors and digital or analog communication, such as in hardware-in-the-loop (HIL) testing, allows to exchange digital- or hardware-measured variables between the digital and real world.

While digital real time simulation has clear potential to flexibly test any hardware in realistically simulated grid conditions, its limitations must be considered. On the opposite of off-line simulations, where a larger size of the simulated network makes the simulation computations only slower, DRTSs must respect hard real time constraints. These constraints mean that the simulated system solution shall be delivered within the desired time step and any overrun results in the interruption and failure of the simulation. As a consequence, the size of the simulated system must stay relatively small to meet computational timing constraints. Increasing the simulation details, e.g. power electronics switches or high-order generator equations, decreases the system scale, that can be solved in a certain time step. These restrictions are exacerbated with simulation of switching power electronics due to computational cost of solving models of their non-linear nature.

This tutorial's goal is to train the researchers approaching digital real time simulation in performing computational time-efficient and accurate simulations of electrical networks, and in particular of power electronics-based ones. The tutorial is structured with a system-to-component level approach. In the first section, we will provide guidelines to the modelling of grid-connected converters so to minimize the computational effort while maintaining the accuracy required by the specific design or analysis objective. In this section we will focus on test scenarios (e.g. primary frequency regulation) that require the modelling of large power systems with a high number of converters. Those models target a time step of a few tens of microsecond.

While in the first section we will mainly focus on averaged converters models and control representation, in the second section we will review well known techniques for the switching representation of power converters, and we will analyze how the different modeling approaches affect the computational effort. We will then focus on scenarios that require a switching representation of power converters. The focus will still be on analysis and systems that require a microsecond-level time resolution.

In the third section we will then analyze how power converters can be modeled to achieve switching representations while targeting time steps below one microsecond. We will review the benefit and limits of dedicated execution approaches as well as of the use of field programmable gate array (FPGA) based platforms. The focus in this case is the simulation of microgrids scenarios with high frequency power converters (50 to 200 kHz).

During the tutorial we will make large use of code examples and exercise. The tutorial will take an agnostic approach in respect to commercial solutions, all examples will be based on open-source software and will be provided to the attendees. While some of the code examples presented could be used directly for real time simulation also on FPGAs we are aware that most of the attendees will use commercial platforms more readily available in their engineering and research activities. The goal of the provided examples and exercise is to highlight the fundamental modeling choices that exist for simulation of power converter-based power systems and provide informed guidelines that the attendees can then use with commercial tools.

T7(PM): Advanced Control of Power Electronics Systems

Instructors:

- Sudip K. Mazumder, University of Illinois, Chicago
- Tobias Geyer, ABB Drives
- Debanjan Chatterjee, ABB Corporate Research

Abstract: This tutorial provides a fundamentally different perspective on multi-scale control of switching power electronic systems along with plurality of practical experimental results and is expected to be of great interest to the power electronic system engineers, professionals, educators, and students. Many new materials are planned for this tutorial with several recent developments. The tutorial will start with basics for researchers, engineers, professionals, and students and gradually work its way through to intricacies in advanced control concepts, realizations, and practical implementations for advanced control realizations on new topologies and control platforms.

It is based on controlling the time evolution of the switching states (i.e., switching sequences) as well as controlling the switching transition of the power semiconductor device of the solid-state electronic system. The former – i.e., switching-sequence-based control yields rapid response under transient condition, optimal equilibrium response, and yields seamless transition between the two states of dynamics.

The first part of the tutorial will primarily focus on switching-sequence-based control for power electronics systems. By enabling integration of modulation and control, switching-sequence-based control precludes the need for ad-hoc offline modulation synthesis. In other words, an optimal switching sequence for the power converter is generated dynamically without the need for prior determination of any modulation scheme (which generates a pre-determined switching sequence) in typical conventional approaches.

One of the fundamental distinctions between switching-sequence-based control and conventional model predictive control is that the former ensures optimal determination of the switching sequence of the power converter under stability bound. The tutorial will provide the mechanism to carry out switching-sequence-based control and model predictive control syntheses and demonstrate the differences between the two optimal control schemes.

Several device, converter, and network-level implementations (e.g., microinverter, solar inverter, pulsed-power systems, microgrid, parallel inverters, multilevel converter, aircraft power system) of the switching-sequence-based control will be provided, encompassing the author's multiple years of project experience encompassing leading advanced defense and energy industries.

Finally, the tutorial will focus on switching-transition control. The primary objective of this control is to demonstrate how key power electronic system parameters including dv/dt and di/dt stress, switching loss, and electromagnetic noise emission can be controlled dynamically by modulating the dynamics of the power semiconductor devices. Both electrical and newly developed optical control mechanisms to achieve switching transition control will be demonstrated. In the context of the latter, mechanisms for monolithic integration of switching-sequence control as well as switching-transition control will be outlined and the revolutionary impact of such a novel integration on system performance will be demonstrated with numerous recent and ongoing practical applications.

The second part of the tutorial reviews control methods that fully exploit the performance potential of high-power converters, by ensuring fast control at very low switching frequencies and low harmonic distortions. To achieve this, the control and modulation problem is addressed in one computational stage.

Long prediction horizons are required for the MPC controllers to achieve excellent steady-state performance. The resulting optimization problem is computationally challenging, but can be solved in real time by branch and bound methods. Alternatively, the optimal switching sequence to be applied during steady-state operation—so-called optimized pulse pattern (OPP)—can be pre-computed offline and refined online to achieve fast closed-loop control. To this end, the research vision is to combine the benefits of deadbeat control methods (such as direct torque control) with the optimal steady-state performance of OPPs, by resolving the antagonism between the two. Two such MPC methods are presented in detail.

T8(AM): Virtual Synchronous Machines - Inverters for a Stable and Well-damped Grid

Instructors:

- Radu Bojoi, Politecnico di Torino
- Fabio Mandrile, Politecnico di Torino
- George Weiss, Tel Aviv University
- Florian Reissner, Tel Aviv University

Abstract: The current shift from fossil-based energy production towards renewable power in the electric grid, as well as the integration of battery storage systems (BSSs) and the bidirectional V2G, are radically challenging the power grid due to the proliferation of static power converters (inverters). Without new approaches to inverter control, the associated drop in overall system inertia and damping decreases and deteriorates the grid's stability and robustness against disturbances and faults.

A promising solution to this challenge is the Virtual Synchronous Machine (VSM): inverters behaving like synchronous generators to provide grid services and grid support. Therefore, the VSM-controlled inverters can contribute to system inertia, damping and the decentralized regulation of voltage and frequency. Moreover, their very fast response time, and their ease of reprogramming to add new features in their control algorithm, opens ways to improve their performance beyond what is possible with synchronous generators.

This tutorial will start by presenting requirements for safe grid operation and stability requirements that impose bounds on damping and inertia from the power electronics perspective. Then, the concept of VSM will be presented and its advantages compared to other control strategies are highlighted.

We analyze the performance of a microgrid comprising VSMs in island mode as well as when connected to a main grid. We also consider microgrids comprising both VSM and synchronous machines and show the interdependence between system parameters, VSM parameters and the physical equipment of the inverter. Finally, we introduce more advanced concepts for the safe and stable operation of VSMs: the influence of measurement errors and grid voltage distortions, black start mechanisms and ways to improve the damping of oscillations and fault ride-through using communication links between inverters.

T9(AM): Electric Propulsion: Challenges and Opportunities

Instructors:

- Jin Wang, The Ohio State University
- Tom Jahns, University of Wisconsin
- Bulent Sarlioglu, University of Wisconsin
- Patrick McClusky, University of Maryland
- John Kizito, North Carolina A&T University
- Julia Zhang, The Ohio State University

Abstract: For better fuel economy and carbon oxide reduction, future aircrafts call for electric propulsion. Though there have been significant developments in electric machines and power electronics in the last few decades, electric propulsion presents significant challenges and opportunities.

At the system level, the high power rating of the electric propulsion calls for higher distribution voltage. Currently, the distribution voltage for more-electric aircraft is limited to 540 V because of partial discharge related issues. In the future, where a single aisle commercial aircraft will require more than 10 megawatts of propulsion power, the electric power distribution voltage is expected to reach as high as 4 kV, which presents a significant challenge in the system architecture and insulation designs.

At the sub-system level, to realize high fuel economy, electric machines and power electronics drives are expected to have ultra-high power densities of 14 kW/kg and 25 kW/kg, respectively, which requires significant innovations in material, device, machine structure, power electronic packaging, control and thermal management.

This tutorial will start with an introduction of different types of turbo and hybrid propulsion systems and state-of-the-art of power electronics and electric machines for aircraft. Then the tutorial will first focus on the partial discharge phenomena at low air pressure and how it will affect the designs of power electronics and electric machines. Newly published results on partial discharges in motor windings and power modules with silicon carbide (SiC) based high dv/dt waveforms will also be presented.

On the topic of integrated high power density motor drives, the tutorial will first introduce the state of the art high specific power electrical machines for various sectors of the aviation hybrid/electric space. Differences in requirements and challenges for each sector will be discussed. The pros and cons of different machine topologies including various stator structures, winding configurations and rotor configurations will be discussed highlighting key opportunities and challenges. Key factors in terms of achieving high specific power such as advanced thermal management and advanced materials will also be introduced.

Then, the development status of SiC devices and megawatt-level power converters will be discussed. A case study based on state-of-the-art commercially available SiC power modules will be presented as an example. The high-power-density, partial-discharge-free design together with test waveforms will be presented.

The last main part of the tutorial is dedicated to the thermal management of the propulsion system for future hybrid and electric aircraft. Specific challenges in thermal designs for aerospace applications will be introduced first. Then multiple advanced thermal design approaches for integrated electric machines and power electronics will be discussed in detail.

Though the material presented in this tutorial is aerospace application oriented, the knowledge presented on high-power-density electric propulsion systems can be extended to many applications where high power rating, high power density and high efficiency are expected.

T10 (AM): Solid-State Transformers – Fundamentals, Industrial Applications, Challenges

Instructors:

- Johann W. Kolar, ETH, Zurich
- Jonas Huber, ETH, Zurich

Abstract: Solid-state transformers (SSTs) provide isolation and power flow control between medium-voltage (MV) and low-voltage (LV) ac or dc systems and are formed by input- and output-side power electronic converters, which are linked through a medium-frequency transformer (MFT). Accordingly, SSTs are expected to show high power density and offer full controllability of the terminal currents and/or the transferred power and, in case of ac voltages, the reactive power at the input and the output side.

Therefore, SSTs are considered for replacing bulky low-frequency transformers (LFTs) of high-power EV charging stations, datacenters, or traction vehicles, and are in general seen as key elements of future smart microgrids. However, the connection to MV and the thus necessary overvoltage protection, the high overall complexity, the relatively high realization costs, and the potentially lower efficiency in case of ac-ac conversion are still major challenges for practical applications.

The tutorial starts with a brief review of transformer scaling laws and then identifies the motivation, requirements, and challenges associated with SST applications. Next, we discuss the most important conceptual and design aspects of SSTs such as single-cell vs. multi-cell topologies using Si or SiC semiconductors, isolated front-end vs. isolated back-end converter architectures, reliability of multi-cell converters, MFT realization, and protection concepts. In this context, we also present the latest results of research at ETH Zurich, which currently targets advanced air-core medium-frequency transformer designs considering close similarities to high-power wireless power transfer systems.

The second half of the tutorial then provides comprehensive application-oriented evaluations of industrial SST demonstrator systems in their application context, whereby a focus lies on emerging applications such as MVAC-LVDC interfaces for future datacenters or high-power EV charging stations. For each example, we fairly assess advantages and drawbacks compared to alternative solutions (e.g., based on LFTs and high-efficiency LV SiC converters), regarding relevant performance metrics such as power conversion efficiency, power density, cost, complexity, robustness, and reliability/availability.

We close the tutorial by distilling these comparative evaluation results into the identification of the most promising future SST applications and concepts but also of the remaining key challenges such as robustness, protection, and cost, which need to be addressed in the course of future research for SST technology to enable a breakthrough.

The tutorial is tailored to serve the interests of a broad audience with academic or industrial backgrounds.

T11(PM): Design and Control of Solid-State DC Transformers for DC Transmission and Distribution Grids

Instructors:

- Rik W. De Doncker, RWTH Aachen University
- Jingxin Hu, RWTH Aachen University
- Shenghui Cui, Seoul National University
- Subhashish Bhattacharya, North Carolina State University

Abstract: The transition from a predominantly fossil fuel-based power generation towards renewable power sources, predominantly wind turbines and photovoltaic systems, inevitably leads towards an energy supply system that greatly depends on power electronics to feed the energy in the electrical grid. As all power electronic driven systems are intrinsically dc sources or loads, dc transmission and distribution systems become evident, not only because it is more efficient and cost effective, but also increases the ampacity of cables.

The development and commercialization of medium-voltage, multi-megawatt dc-dc converters, also called solid-state dc transformers, is a key enabler to realize flexible and interconnected dc grids. Compared to ac transformers, solid-state dc transformers not only need to transform voltage and control power flow, but also need to offer similar efficiencies (up to 99%) at high switching frequencies, provide the same insulation levels and limit fault currents, that is, offer fault-ride-through capabilities.

In this tutorial, we introduce and describe the latest advances and best practices of galvanically isolated bidirectional dc-dc converters for solid-state dc transformers. This tutorial covers a wide selection of key enabling technologies from converter topologies, optimized control, to the design of highly efficient megawatt medium-voltage dc-dc converters based on emerging MV SiC devices.

Following a general introduction and a technology roadmap of dc transmission and distribution grids, the tutorial will elaborate on the most promising candidates of bidirectional isolated dc-dc converters for solid-state dc transformers. It will start with a comprehensive comparison between single-phase and three-phase dual-active bridge (DAB) converters for LV and MV dc applications, where the pros and cons are clearly underlined.

Further, advanced modulation and control of the DAB converter will be presented to overcome two important challenges. First, the trajectory modeling approach and the instantaneous flux and current method are systematically presented to explain and resolve the transformer saturation issue under dynamic conditions.

Second, the asymmetrical duty-cycle control method is introduced to enable ultra-wide voltage operation of the DAB converter with soft-switching and the fault ride-through capability.

Considering the numerous benefits of the bipolar dc distribution, the tutorial will also present advancements in power conversion technologies for bipolar LVDC and MVDC distribution systems. Several novel converter topologies of dc-dc converters for LVDC and MVDC applications will be addressed, which are inherently capable of bipolar operation. These topologies are based on the concept of topological integration of voltage balancers, which are required individually for maintaining voltage balance of bipolar dc grids. With such integration technique, bipolar operation capability of dc-link can be obtained with minimum costs and conversion losses.

The last section of the tutorial will focus on the understanding of MV SiC devices (15-kV IGBTs versus 15-kV MOSFETs; and 10-kV, 6.5-kV, and 3.3-kV MOSFETs) and their applications for the MVDC grid. MVDC grids will be explored with demonstrated and pilot application examples of SST (solid state transformer). The roadmap of MV SiC power devices in terms of cost targets, module packaging, and reliability qualification of MV SiC devices will be addressed. Advances in medium-frequency magnetics for wide-bandgap (WBG) device-based power converters and especially for high-power converters, with latest advances in magnetic material qualification and characterization will be included.

T12(PM): Motor drive design and evaluation using multi-domain tool suite for faster development process

Instructor:

- Albert Dunford, Altair Engineering

Abstract: A key objective with all designers is to reduce development time and costs. Motor drive development requires teams from different domains to work closely during the design process which involves design and development of the motor, power converter hardware, control algorithms, PCBs, automatic embedded code generation, EMI, etc. Simulation allows for rapid development and testing. A proper tool suite that can cover various aspects of the motor drive development process will allow more to be done in simulation, so that when prototypes are built, they can be tested and verified with confidence. Better prototyping means fewer design iterations to prove a design is ready for production deployment

This tutorial will present design workflows that leverage the full suite of Altair's tools for a comprehensive simulation to production grade motor drive development. The following aspects of the drive development will be considered:

- Power converter hardware design including device selection such as IGBT vs SiC devices
- Motor design
- Close loop control design
- Non-ideal switch models, PCB parasitics, and analysis of conducted EMI
- Complete motor drive efficiency map
- Embedded firmware development and verification
- System-level simulations such as torque speed load profiles, mechanical structure impacts and tuning control gains via interactive hardware in the loop.

Where applicable automation and scripting will be utilized to reduce manual activities required by designers.

- The tutorial will showcase how different design tools can be used in various design stages. PSIM, power electronics simulation
- Flux, machine FEA simulation
- Activate/compose, system model control and scripting
- Pollex PCB design

- Embed, model-based automatic code generation for drive development
- Motion solve.

T13(PM): Electric Vehicle Batteries and Charging Systems: A Primer

Instructors:

- Ashish Arora, Exponent
- Rita Garrido Menacho

Abstract: A number of automobile manufacturers have released electric vehicles (EV) over the past few years with an even larger number of EV models being prepared for release in the not too distant future due to the demand for clean energy and reduction in carbon emissions. The charging infrastructure for these vehicles is also aggressively being rolled out by different organizations.

While Lithium-ion (Li-ion) cells have been around for decades powering a variety of consumer electronic devices, their use in electric vehicle applications is relatively new. The requirements that the cells have in these applications where hundreds if not thousands of cells are connected together are completely different from the requirements that the cells have in consumer electronic products due to many factors including the significantly higher battery operating voltages in EV applications. Similar challenges also exist for the charging infrastructure required to power these vehicles.

A number of organizations in the world have developed standards that guide the design and development of both EV batteries and chargers. These standards address everything from crash worthiness requirements for the vehicles and their batteries, to the requirement for the batteries to be designed with passive propagation resistance that prevents a single cell thermal runaway condition from propagating and resulting in a larger failure. Relatively newer standards also require vehicles to provide a 5-minute warning to the driver of possible fire ingress into the passenger compartment due to a thermal runaway in the battery.

The tutorial will start with a basic overview of Li-ion cells and then delve deeper into how these cells are incorporated in EV battery packs and the infrastructure required to keep the cells operating both safely and reliably. The tutorial will also address the need for passive propagation resistance and how this is achieved in EV battery packs on the road today. The discussion on EV batteries will include an overview of the reliability and abuse standards that have been developed around the world and how these standards dictate some of the design aspects of EV batteries.

The second half of the tutorial will focus on EV chargers. EV chargers are designed with different capabilities. The tutorial will discuss the various EV charger designs that have been deployed in the field and the advantages and limitations of these chargers. This section of the tutorial will also detail the various EV charger standards and the requirements in these standards.

The tutorial will end with a discussion on recent EV battery and charger recalls and detail two case studies: one focused on an EV battery failure in the field and the second detailing the failure of an EV charger that resulted in an electric shock to a user.

T14(AM): Recent Advances on Modular-based Multilevel Voltage-Source Converter (VSC) for MV and HV applications: Principle, Control, and Its competitiveness with MMC

Instructors:

- Dong Dong, Virginia Tech
- Di Zhang, Naval Postgraduate School

Abstract: The global electrification trend in power grid and transportation accelerates the demand for high-performance, high-density, and high efficiency ac-dc power conversion system in the medium-voltage (MV) and high-voltage (HV) areas ranging from a few kilovolts to hundreds of kilovolts. The conventional voltage-source converter (C-VSC) cannot meet such demand due to limited range of voltage offering, poor power quality, slow dynamic-response, and last but not least, long development and test cycle.

Since the invention of modular multilevel converter (MMC) technology, it quickly dominated the high-voltage direct current (HVDC) VSC market and penetrated to the MV grid-interface applications like STATCOM. The modular-in-nature solution offered by MMC fundamentally changed the way of building MV and HV converters. However, MMC still faces several challenges like large footprint, high-cost, and low-efficiency, making it face a strong competition from the C-VSC in the MV area. Therefore, combing the benefits from both MMC-VSC and C-VSC are strongly desired for next-generation modular-in-nature VSCs.

This tutorial will summarize and present an overview of the most recent research progress on various modular MV/HV VSC converter topologies, including alternative-arm-converter (AAC), asymmetric alternate arm converter (AAAC), hybrid modular-multilevel converters (HMMC) and hybrid modular-multilevel rectifier (HMMR), as the next-generation solution beyond both MMC and C-VSC.

The basic operational principle, topological derivation, modeling and control, and apple-apple comparison with MMC in terms of efficiency, cost, and size will be discussed. Several emerging and existent MV and HVDC application cases will be presented to showcase the detailed HMMC/HMMR use cases and their competitiveness to surpass MMC and C-VSC as the next-generation VSC solutions.

T15(PM): Best Practices for Low-Power (IoT/IIoT) Designs: Separating the Source-Side & Load-Side Analyses

Instructor:

- Brian Zahnstecher, PowerRox

Abstract: The Internet of Things (IoT) and Industrial IoT (IIoT) have come a very long way from emerging topics to driving mainstream, high-volume products across every major market space today. This has been enabled by innovation on the source-side and load-side of the system power budget and related Power IoT ecosystem.

On the load side, Moore's Law has provided much of this enhancement, but a key value proposition that has also made a major impact in minimizing system power budgets has been in intelligent power management (IPM) and the optimal control of loads that focus on best practices in utilization, particularly for battery-powered deployments. On the source side, advancements in energy storage coupled with the inclusion of ambient energy scavenging or energy harvesting (EH) techniques drive increased battery life and even total (primary) battery mitigation in some applications.

A great deal of the opportunity in improving system design for the most energy-efficient design practices comes in the convergence of the source-side and load-side optimization techniques. These worlds converge in subsystems and circuits related to battery management systems (BMSs), power management ICs (PMICs), and smart management of major power consumers such as sensors, displays, and wireless networking.

Any design engineer and/or related developer knows that meeting a battery life target is far more convoluted that merely adding up maximum system loads, identifying a steady-state current draw for operation/sleep, and dividing those values by maximum-rated battery capacity. In fact, just about any battery-powered design will result in a "sticker shock" of just how surprisingly disappointing the gap ends up being between calculated and measured battery life. Systems also integrating some aspect of a self-powered energy source (such as EH) can contribute many more variables to these calculations and require consideration and analyses that go far beyond that of a typical system power budget architecting exercise.

This entry-to-intermediate-level tutorial will address all the aforementioned by starting with a breakdown of what the primary design challenges are and how to view them in terms of impact to optimal energy efficiency/utilization. This is followed by a review of solutions and best practices to address these challenges, deep diving into the highest-impact areas of focus (i.e., understanding batteries/storage and impact to component life, taking advantage of environmental factors, minimizing overhead especially for sensors/networking, and more). As the tutorial title implies, most of these high-level agenda topics will be covered from source-side, load-side, and interactive, system perspectives.

The content is primarily geared toward design engineers, but shall be presented in way that directs the best practices and messaging to a variety of ecosystem stakeholders ranging from technical to project management (including business perspectives) to supply chain and manufacturing. A constant stream of low-cost tips and tricks, design resources/tools, and other things that accelerate time-to-market (TTM), while maintaining high quality, will be presented. Where appropriate, there will also be content discussing barriers to market and case studies or use cases to demonstrate the most salient points.

T16(PM): Design Strategies for High-Power, High-Current, Isolated DC-DC Converters using Soft-Switching Technology and Silicon Carbide Transistors

Instructors:

- Mark Scott, Miami University
- Alexander Isurin, Vanner

Abstract: Engineers must be familiar with and understand the many nuances of their design space to create a successful product. It takes time and experience to gain this knowledge. This tutorial lowers the learning curve for engineers (and researchers) developing isolated dc-dc converters. It presents design guidelines for implementing silicon carbide (SiC) power devices in isolated dc-dc converters that use soft-switching technology.

It targets hardware with a high conversion ratio at power levels of 2 kW and beyond. In these applications, the high-voltage terminals operate at hundreds of volts and the low-voltage terminals conduct several hundred amps. It covers both isolated dc-dc converters and active rectifiers based on isolated dc-dc converters. Overall, the knowledge and experience shared are broadly applicable to multiple industries and applications.

The tutorial begins with an overview of isolated dc-dc converter applications in the automotive and aerospace fields as well as their associated design challenges. Then, it outlines how one selects a power supply topology for a given application using the specified metrics—cost, reliability, compatibility, size, and weight. Next, the attention turns to SiC power devices. The presenters compare SiC components to traditional power devices like silicon (Si) MOSFETs and IGBTs. This comparison includes datasheet analysis and experimental validation.

This is followed by a discussion on passive components. Afterward, the tutorial reviews soft-switching technology and then dives into multiple topologies. Finally, the speakers address high-current, high-frequency transformers. They present various design strategies and provide experimental results for multiple implementation methods. The talk ends with a summary of the main talking points.

Upon completion of the tutorial, audience members will feel more comfortable using SiC components in their designs, regardless of the topology or application. They will also be more confident selecting an isolated dc-dc converter for their application, implementing soft-switching technology, and specifying the resonant components for their design.

T17(PM): Emerging Cybersecurity Challenges in Modern Energy Systems – Assessment and Solutions

Instructors:

- Subham Sahoo, Aalborg University
- Yan Li, Penn State University
- Charalambos Konstantinou, King Abdullah University

Abstract: Cyberattacks on critical infrastructure can have a debilitating effect on national economic security, public health, and safety. The underlying processes of the critical power infrastructure sector controlled by the information and communication technology-based elements employed into power electronic systems, create a close coupling between the cyber and physical components. This transition greatly expands the attack surface of such systems, as cyberattacks targeting commercial-off-the-shelf hardware and software are well-known.

In this context, this tutorial not only aims to establish the scientific know-how comprising a framework from basic to advanced topics on power systems and power electronics security, but also plans to demonstrate its impact on different operation layers from lab-scale resources. The first part of the tutorial will emphasize providing context on building testbeds for security studies, providing guidance on recognizing weaknesses, which can be valuable to attackers. It then aims at, along with threat modeling and risk assessment strategies, the modeling, resources, and metrics for industrial control systems security studies.

Case studies on cyberattacks and defenses will be presented in a hardware-in-the-loop environment using OPAL-RT real-time simulator and EXataCPS emulator. Moreover, different cases of attack strategies will be simulated under nominal and abnormal operating conditions to uncover their system-wide impacts in power systems, as well as illustrate the impact of such attacks. The feasibility of the detection methods leveraging the hardware layer will then be investigated from a system resiliency perspective.

The second part of the tutorial will then put a spotlight on resiliency metrics against cyber-attacks across much faster dynamics in the microgrid scale. Keeping these issues in view, a stepwise design of software-defined networking (SDN) technique will be introduced to build the communication network, with the objective of enabling the network’s real-time configuration ability.

Three typical SDN planes will be introduced, namely, data plane, control plane and application plane. Their separation is designed to manage the data traffic and generate extensible functions such as cyberattack detection. Considering the holistic visibility of SDN also makes the system vulnerable to cyberattacks, the model-based programmable cyberattack detection and defense strategies will be introduced to secure the SDN network in microgrids. A demonstration will be provided to showcase the programmable detection and defense strategies.

Finally, the third part of the tutorial will generally focus on the impact of cyber attacks on operation management of power electronic systems. Generalization from projections of cyber attacks on stability and reliability of the grid will first be carried out using a self-healing mechanism. Furthermore, different methodologies to model cyber attacks will be explained in detail, which are programmed to be introduced into the systems as faults.

To characterize between various malfunctioning events and cyber attacks, the design of anomaly detection tools will be explained. Finally, demonstration videos from experimental prototype will be shown to examine the performance of the self-healing mechanism under different cyber attacks, faults, unstable events. Moreover, its efficacy to restore the system back to normally and protect the physical infrastructure from cyber attacks will be analyzed in detail.

T18(AM): Advanced power conversion systems for next-generation wireless battery charging

Instructors:

- Deepak Ronanki
- Sheldon Williamson
- Mauricio Esguerra

Abstract: Electrification of the transportation sector is essential to avoid irreversible climate change. As electrified transport systems proliferate, the development of battery chargers and their infrastructure is becoming crucial for the long-term and commercial success of these systems. The batteries in the electrified vehicles are recharged through on-board/off-board conductive and wireless chargers, which are fed from the grid and/or renewable energy resources.

Conductive battery chargers are well established and more popular due to their high efficiency; however, handling high-power cables during adverse weather conditions is a risk of electric shock. Furthermore, wireless charging is considered to be the notable solution for opportunity charging of electrified vehicles especially for brief stops or traffic intersections and reduce the battery size under in-motion charging.

While there have been many articles published on power conversion systems including power converters and couplers, this tutorial approaches the problem from basic to advanced levels. Understanding wireless chargers and their application from basic and advanced level for future transportation are crucial. Additionally, this tutorial will discuss the design process and simulations through case studies.

Power converters convert ac to high-frequency ac (HFAC) and HFAC to dc on the vehicle side in WPT charging. Coupling devices are equipped to transfer power through electromagnetic/static coupling, and compensation circuits are connected on-road and vehicle side to reduce VA rating. The primary converter is operated corresponding to the feedback signal from the battery through wireless communication.

This tutorial provides a practical introduction and technical advancements in wireless power transfer (WPT) based battery charging systems regarding the theoretical analysis, design, modelling, control, and simulation. Its focus is on the summary of inductive, capacitive and hybrid EV battery charging architecture with related examples and an in-depth discussion of WPT chargers design on various simulation platforms. It provides a step-by-step design of different WPT systems including the inductive and capacitive couplers, and then a comprehensive understanding and design of dual-stage and single-stage power conversion systems. The objective is to expose the audience to all facets of WPT systems with an emphasis on the hands-on tools required for executing academic research and for meeting industry expectations.

T19(AM): Advanced Magnetic Designs Enabling Electrification of High Power Industrial Systems

Instructors:

- Paul Ohodnicki, University of Pittsburgh
- Brandon Grainger, University of Pittsburgh
- Byron Beddingfield, North Carolina State University
- Subhashish Bhattacharya, North Carolina State University

Abstract: This tutorial will outline the emerging technologies in co-optimization of converters by highlighting recent developments in magnetic materials for wide bandgap (WBG) power electronics and component design. The tutorial will provide design examples showing how these technologies are enabling the electrification of high power systems for industrial applications. It will also highlight the research conducted at the industry and university consortium for Advanced Magnetics for Power and Energy Development (AMPED).

Leveraging extensive experience in high power/voltage power converters in multiple industry sectors—HVDC, FACTS, MV converters for high-speed motor and traction drives, MVDC and ac grid enabling SSTs (solid state transformers), and shipboard SSTs, the team will demonstrate and provide tools for using emerging magnetic materials and postprocessing techniques, e.g., ferrites and advanced amorphous and nanocrystalline alloys, spatially tuned properties, and heterogeneous materials.

The improvements required in efficiency, power density, specific power, and volumetric density metrics needed to enable multi-MW converters are forcing the industry to re-evaluate the present state-of-the-art SiC based power converters. With the use of new and advanced magnetic component design, the benefit of SiC converters can be fully realized. Furthermore, the concepts provided in the tutorial will also highlight the pathways towards enabling ultra-wide bandgap (UWBG) devices with the research in new magnetic material development.

The opportunities for HV SiC devices for MV and high power converters and utility applications and the challenges to apply these HV SiC devices successfully will be presented in-depth with SiC device voltage ranges from 1200-V to 1700-V MOSFETs, and HV SiC 10-kV to 15-kV MOSFETs, JBS diodes, and 15-kV SiC IGBTs and the newly developed four-quadrant 1200-V, SiC BiDFET (Bi-directional FET) switches.

The potential and challenges of emerging magnetic materials and components design will be explored with demonstrated application examples of SST, MV SiC power converters for grid-tied solar applications, MV motor drives, shipboard power supply applications, and MVDC grids. The roadmap of HV power devices and magnetics will be addressed in terms of cost targets, module packaging, reliability qualification, and standards compliance of HV SiC devices.

T20(PM): Pulse energy modulation v.s. pulse width modulation for single-phase power inverters with power decoupling technologies

Instructors:

- Shuang Xu, University of New Brunswick
- Meiqin Mao, Hefei University of Technology
- Liuchen Chang, University of New Brunswick

Abstract: As the power electronics industry has developed, various families of power electronic inverters and rectifiers have evolved, often linked by power level (single- or three- phase), switching devices, and topological origins. The process of switching the electronic devices in a power electronic converter from one state to another is called modulation. The most popular modulation strategy for controlling the ac output of bridge inverters is known as carrier-based pulse width modulation (PWM), which varies the duty cycle of the inverter switches at a high switching frequency to achieve a target average line-frequency output voltage or current.

This tutorial provides a comprehensive overview of the evolution of single-phase converter topologies underlining power decoupling techniques and the development of various PWM techniques and pulse energy modulation (PEM). Different from most carrier-based PWM techniques, PEM employs energy reference rather than the voltage or current reference to compare with the carrier waveform to produce the triggering signals.

Conventional passive power decoupling techniques paralleling a large electrolytic capacitor at the dc side were commonly used in single-phase power converters to buffer the second-order power mismatch. In recent years, as the active power decoupling technologies advance, it is promising to reduce the capacitance of the dc-link capacitor to enable the use of small film capacitors and extend the lifetime of the overall converter system, by employing independent power decoupling circuits such as bidirectional converters or dependent power decoupling circuits that share power electronic components with original converters.

The active power decoupling topologies have evolved on three branches: current-reference, dc voltage-reference and ac voltage-reference. The tutorial presents benefits and drawbacks of each topology as compared with its predecessor in an underlying logic way, enabling the audience to develop a systematic methodology to come up with new solutions for their own applications. In addition, a general comparison has also been made in terms of decoupling capacitance/inductance, additional cost, efficiency and complexity of control, providing a benchmark for future power decoupling topologies.

Finally, a 10-kW single-phase power inverter system is used as an example in the case study of power decoupling project at the Research Center for Photovoltaic System Engineering of Hefei University of Technology in China. The electrolytic capacitor of millifarads is replaced by a smaller film capacitor of ~200 µF through topological and algorithmic designs, where a direct input current predictive control technique is used to achieve the power decoupling function.

T21(AM): Extend the lifespan of electric vehicle batteries in their second life for renewable and smart energy grids

Instructor:

- Chris Mi, San Diego State University

Abstract: Electric vehicles (EVs) started to enjoy a booming market share since the last decade. The number of EVs on the roads is enormous and keeps growing rapidly, and so is the quantity of EV batteries. It is estimated that the first huge wave of EV battery retirement in California will hit in 2025, and retired batteries will keep coming thereafter. EV batteries today, almost exclusively lithium-ion based, cost heavily in both production and recycling. Economically dealing with retired EV batteries is an important topic.

Renewable energy, such as solar and wind, currently has a high penetration rate especially in sunshine-rich states like California. Battery energy storage systems (BESSs) are frequently incorporated with PV and wind power systems as a standard approach to buffer the volatile nature of the energy output. Household small PV and storage systems are popular products in the market. For commercial buildings, similar technology is also available, but normally featuring large and centralized battery stacks and consequently high cost. The high cost of new batteries in renewable and grid storage systems could be a major discouragement for potential clients, especially small/medium business owners.

Retired EV batteries, though no longer roadworthy in the vehicle, still have considerable capacity for stationary applications where the requirement for energy and power density is not as stringent. As an abundant byproduct from the road, these second-life EV batteries cost much less than new products. Thus, developing proper technologies to bridge the supply and demand has great significance.

This tutorial will holistically look at the life cycle of electric vehicle batteries, and how they can be used in energy storage systems after they are retired from electric vehicles. The tutorial will include storage system design, battery management, battery balancing, size optimization, and system control and optimization for demand charge management and peak shaving. It will also look at the various testing requirements for identifying the conditions of used EV batteries. The aging mechanism of second-life EV batteries will be presented.

T22(PM): The benefits of infrared thermography testing for the thermal management in energy storage and conversion

Instructor:

- Stephan Larmann

Abstract: Power electronics components are pivotal for the development of efficient power conversion systems. New materials being applied allow for a better performance but are also extremely challenging in terms of their thermal behavior. Therefore the monitoring of exactly this thermal behavior of power electronics components and systems becomes increasingly important.

This tutorial discusses the usage of infrared thermography in monitoring the thermal stress single power electronics components as well as complete systems may undergo being operated. A sensible test set-up is influenced by the high temperatures modern power electronic materials can operate at, the small component size and the need for high switching speeds in systems for energy conversion.

The very focus of the tutorial will be on hands-on test examples to explain step-by-step the critical success factors for such measurements. Participants shall be empowered to apply infrared thermography in their specific field of research based on a sound understanding of the physical fundamentals of this measurement technology.

T23(PM): Factors influencing active torque ripple cancellation in PMSM/IPMSM drives

Instructor:

- Ramakrishnan Raja, Halla Mechatronics

Abstract: In this tutorial the main goal is to go in detail to understand various factors that need to be considered to do an efficient active torque ripple cancellation for a PMSM/IPMSM drive at all operating conditions. In this tutorial we will take a 12-V 1-1KWPMSM/IPMSM machine for the case study and analyze how different sensor error and non-linearities affect the torque ripple at different operating condition.

The tutorial will also deal with how to develop a high bandwidth current loop and also various challenges in regard to current control of the PMSM drive with respect to doing effective torque ripple cancellation at all operating conditions. Finally, it will conclude with various key factors that need to be considered in selection of the motor position and current sensor in order to achieve effective active torque ripple cancellation for mass production.

T24(AM): Power HIL: Enabling Flexible and Repeatable Testing of Power Electronics Systems in Close-to-reality Environment

Instructors:

- Srdjan Srdic, EGSTON Power Electronics
- Igor Cvetkovic, Virginia Tech

Abstract: The growing market need for flexible and repeatable testing of power electronics systems in grid, automotive, aerospace and defense applications, has made power hardware-in-the loop (P-HIL) a very attractive test approach. With P-HIL, test voltages and currents are generated in user-configurable real-time models, enabling emulation of different operating environments for the physical system that is being tested.

A single software-configurable P-HIL test platform can be used to test various systems in different test scenarios and operating environments. This is extremely beneficial because it provides high testing flexibility, reduces system cost, and accelerates product time-to-market. Enabling repeatable automated tests of power electronics systems significantly de-risks product development by reducing time needed for design iteration.

EGSTON Power Electronics is a leading manufacturer of high-performance P-HIL test and emulation platforms, ranging from 100 kVA to 1.2 MVA power. The COMPISO System from EGSTON Power Electronics is the most versatile P-HIL test and emulation platform currently on the market. With four-quadrant operation, 5-kHz large-signal bandwidth, several predefined operation modes and software applications for easier system use in different test scenarios, the COMPISO System is successfully serving the testing market since 2016.

This seminar will include a company introduction followed by an overview of P-HIL concepts and advantages of P-HIL approach in system testing. The COMPISO System emulation and test platform will be introduced, and its many advantages explained using several use cases as examples.

Appendix: Instructor Bios

T1(AM): Maritime Electrification — State-of-the-Art Hybrid Power Systems for Green Marine Transport

Chendan Li (S'13-M'16) received the B.S. degree from Nanjing Agricultural University, Nanjing, China, in 2009, the M.S. degree from the Nanjing University of Aeronautics and Astronautics, Nanjing, in 2012, both in electrical engineering. She got her Ph.D. degree in Aalborg University, Denmark, in 2016 in analysis and control for ac and dc microgrids.

Li was a post-doctoral fellow in the department of Electric Power Engineering at The Norwegian University of Science and Technology (NTNU) while she worked on smart distribution systems, and now works as a researcher for marine electrification in the department of Marine Technology NTNU. Li serves as an associate editor on the editorial board for Electrical Engineering, Springer and has given several talks in the conference including the plenary talk for ISGT Europe 2021 about her research. Her main research interests include analysis and control for ac and dc microgrids, including onboard microgrids, operation of distribution system, stability for power electronics based power systems.

Mehdi Zadeh received the Ph.D. degree in electrical engineering from Norwegian University of Science and Technology (NTNU), Trondheim, Norway, in 2016. From 2016 to 2017, he was with the power electronics industry, working on the development of battery charging systems. In 2017, he joined the Marine Technology Centre at NTNU in Trondheim, where he is currently an associate professor of hybrid power systems and the director of the Marine Electrification Research Lab. His main research interests include ship electrification for low-emission and autonomous shipping, onboard dc power systems, and offshore renewable energy systems.

Sidun Fang received his B.E degree and Ph.D. degree in Chongqing University and Shanghai Jiao Tong University, respectively in 2012 and 2017. Now he is a full professor (Hongshen Young Scholar program) with the School of Electrical Engineering, Chongqing University. His research interest is the integrated transportation and energy systems, especially in maritime applications.

Fang was awarded the Outstanding Graduate prize of Shanghai Jiao Tong University and his doctoral dissertation was nominated as Excellent Dissertation Papers in Shanghai Jiao Tong University in 2017. He has published one book in Springer Nature and more than 30 journal papers as the first author. Since 2015. Fang has been an editor for IEEE Transactions on Industry Applications and International Transactions on Electrical Energy Systems.

Daniel Stroe received the Dipl.-Ing. degree in automatics from "Transilvania" University of Brasov, Romania, in 2008, and M.Sc. degree in wind power systems from Aalborg University (AAU), Aalborg, Denmark, in 2010. He has been with Aalborg University since 2010, from which he obtained his Ph.D. degree in lifetime modeling of lithium-ion batteries in 2014.

Currently, Stroe is an associate professor with AAU Energy, where he leads the Batteries research group and the Battery Systems Testing Lab. He was a visiting researcher with RWTH Aachen, Germany, in 2013. He has co-authored 1 book and over 150 journal and conference papers in various battery-related topics.

His current research interests are in the areas of energy storage systems for grid and e-mobility, lithium-based batteries testing, modeling, diagnostics and their lifetime estimation. He has organized battery and lectured over 10 tutorials in various battery-related topics at, among others, ECCE-US 2015 and 2018, PCIM Europe 2019, EPE ECCE Europe 2018, 2019, and 2021 etc.

Ahmed Abdelhakim (IEEE SM'19) received the B.Sc. and the M.Sc. degrees (with Hons.) in electrical engineering from Alexandria University, Egypt, in 2011 and 2013 respectively, and the Ph.D. degree from the University of Padova, Italy, in 2019. He is with ABB research Sweden since August 2018, where he held several roles, and currently is a principal scientist and R&D project manager, a position he has held since February 2022.

In 2017, Abdelhakim was with the Department of Energy Technology, Aalborg University, Aalborg, Denmark, as a visiting scholar for ten months, where he was working on several research activities. From 2011 to 2014, he was a demonstrator and then a lecturer assistant in Alexandria University. His major field of interest includes power electronics converters and their applications for energy storage and hydrogen systems, investigation of new power converter topologies, and application of wide-bandgap semiconductor devices for high frequency and high-power density power converters.

Abdelhakim has received first classified excellent Ph.D. dissertation award from Società Italiana di Electronica (SIE'19) among Italian universities in 2019. He is also serving as an associate editor with IEEE Transaction on Industrial Electronics and IEEE Transaction on Transportation Electrification.

T2(AM): Power Semiconductors in Electrified Powertrains – Transitioning from Silicon to Wide Bandgap Devices?

Andre Christmann is a lead principal for high power systems at Infineon Technologies and has over 17 years' experience in this area. After completing his Ph. D. degree from Ruhr Universität Bochum in 2000, Christmann worked for three years at the Fraunhofer Institute for Microelectronic Circuits and Systems (IMS Duisburg, Germany) in the area of power semiconductor development.

From 2004 – 2011, he was responsible for the development of power semiconductor modules for hybrid-electric vehicle applications at Infineon Technologies (Warstein, Germany). During this time, he designed the HybridPACK1 module, which became an industry wide standard footprint for automotive power module. In 2011, he transferred to Infineon North America where he took over a position as senior specialist for technology and innovation in the area of power modules. Since 2019, he has worked as a product definition engineer for power semiconductors.

Christmann is the author of several publications, has lead classes in seminars/tutorials and given presentations at international conferences like APE (France), PCIM (Germany), ITEC (USA), APEC (USA) and ECCE (USA). He also holds patents on power module design.

T3(PM): Practical Application of Silicon Carbide(SiC) in the E-Mobility Ecosystem

Anuj Narain is director, power platforms at Wolfspeed where his team is responsible for accelerating adoption of silicon carbide (SiC) into power conversion and motor drive applications through design support, reference designs and ecosystem development. Prior to Wolfspeed, Anuj spent 15 years at Texas Instruments. He holds an MS in chemical engineering from the University of Southern California (USC), an MS in electrical engineering from the University of Texas at Dallas (UTD) and is a certified functional safety engineer from TUV SUD

Adam Anders, manager of power platforms at Wolfspeed, leads a team that supports customer adoption of SiC through a variety of tools including SpeedFit, LTSpice models, evaluation boards, and application notes. Additionally, his team works with other complimentary industry-leading partners to support the complete SiC ecosystem needs including gate drivers, capacitors, magnetics, and test and measurement equipment. Anders holds an MS in electrical engineering from the University of Wisconsin-Madison (WEMPEC) and worked in a variety of power electronics design roles for 10 years prior to joining Wolfspeed.

T4(AM):Circuit Board Layout for Wide Bandgap Power Transistors

Eric Persson is a 40-year veteran of the power electronic industry. His career spans 19 years of hands-on power converter and inverter design, followed by 21 years in applications engineering in the semiconductor industry at Infineon Technologies (formerly International Rectifier). He is a senior principal engineer for wide-bandgap semiconductor applications.

Eric has presented more than 90 tutorials and papers on topics related to applications and practical design aspects of power electronic circuits. He is a regular lecturer for power electronic short-courses at UW Madison for 20 years. Persson holds 15 patents, and is a recipient of the IEEE Third Millennium Medal. He has a BSEE degree from the University of Minnesota.

T5(AM): Model-Based Control Design and Testing with Embedded Code Generation Using the PLECS Toolchain

Beat Arnet is an expert in the field of power electronics, with over 25 years' experience in power converter design for automotive and renewable energy applications. He is general manager for Plexim where he applies his industry experience to oversee the development of the PLECS embedded code generation tools.

Before joining Plexim, Arnet led electric drive component development at Azure Dynamics (AZD) and oversaw the design of power electronics, electric machines, gearboxes and control software. Prior to AZD, he worked at TIAX, consulting for the automotive industry. There he developed hardware prototypes for active Li-Ion cell balancing and battery management, including high-frequency dc-dc converters. Before TIAX, Arnet managed the Control Electronics group at Solectria, contributing to developments in distributed generation (DG) and hybrid electric vehicle (HEV) drives.

Arnet holds a diploma in electrical engineering from the Swiss Federal Institute of Technology in Zurich and received his electrical engineering PhD from the Swiss Federal Institute of Technology in Lausanne. He is the principal inventor of 5 U.S. patents and has authored and co-authored over 15 publications. He is a senior member of IEEE, and is a member of both the Power Electronics and Industry Applications societies.

T6(PM): Power Electronics Modeling for Real-Time Simulation

Giovanni De Carne (S'14-M'17-SM'21) received the M.Sc. degree in electrical engineering from the Polytechnic University of Bari, Italy, in 2013, and the Ph.D. degree from the chair of power Electronics, Kiel University, Germany, in 2018.

He is currently the head of the "Real Time System Integration" Group and head of the "Power Hardware In the Loop Lab" at the Institute for Technical Physics at the Karlsruhe Institute of Technology. He has authored/coauthored more than 60 peer-reviewed scientific papers. His research interests include power electronics transformers, real time modelling, and power- and hardware-in-the-loop testing. He is an associate editor of the IEEE Industrial Electronics Magazine and IEEE Open Journal of Power Electronics. He held several tutorials at international conferences (ECCE, ECCE Asia, PowerTech, ISGT Europe) on the Smart Transformer applications topic. He has organized an international ECPE workshop on Hardware In the Loop in 2021 with large industrial involvement, and he is the technical committee chairman for the IEEE 2022 PEDG conference, to be held in June 2022 in Kiel, Germany.

Matthew Milton received the M.S. and Ph.D. degrees in electrical engineering from University of South Carolina, Columbia, SC, U.S.A., in 2016 and 2021, respectively.

He is currently a post-doctoral fellow researcher with the department of electrical engineering at University of South Carolina, Columbia, SC, U.S.A. His present research interests include real-time software- and FPGA-based simulation approaches and tool development for power electronic and energy system applications, such as in control, digital twinning, and hardware-in-the-loop testing.

Andrea Benigni (S'09-M'14-SM'20) received the B.Sc. and M.Sc. degrees from Politecnico di Milano, Milano, Italy, in 2005 and 2008, respectively, and the Ph.D. degree from RWTH-Aachen University, Aachen, Germany, in 2013. From 2014 to 2019, he was an assistant professor with the Department of Electrical Engineering, University of South Carolina, Columbia, SC, USA. Since 2019 he is a full professor at RWTH-Aachen and director of the "Institute of Energy and Climate Research: Energy Systems Engineering (IEK-10)" at the Juelich research center.

Benigni has worked in the field of real-time simulation and hardware in the loop testing for more than ten years, and has published several papers on the use of those technologies and on the definition of parallelization algorithms that allow nanosecond resolutions in the real-time simulation of power electronics systems. He is the general chair of the 1st International workshop on "Open Source Modelling and Simulation of Energy Systems" (OSMSES 2022) and chair of the technical committee on Smart Grid of the IEEE Industrial Electronics Society. Through the years he has organized several special sessions at IECON, ISIE and INDIN and served as publicity chair for the IEEE Electric Ship Technologies Symposium (ESTS 2019).

T7(PM): Advanced Control of Power Electronics Systems

Sudip K. Mazumder received his Ph.D. degree from Virginia Tech in 2001. Since 2001, he has served as a professor at the University of Illinois Chicago (UIC) and the director of the Laboratory for Energy and Switching-Electronic Systems. He has also served as the president of NextWatt since 2008. He has around 30 years of professional experience encompassing academia and leading industries. Mazumder was named a fellow of the American Association for the Advancement of Science (AAAS) in 2020 and a fellow of the Institute of Electrical and Electronics Engineers (IEEE) in 2016 for distinguished contributions related to the field of multi-scale control and analysis of power-electronic systems.

He served as a distinguished lecturer for the IEEE Power Electronics Society (PELS) between 2016 and 2019 and currently serves as a PELS regional distinguished lecturer for the U.S. region. He is the current editor-at-large for IEEE Transactions on Power Electronics. He is the recipient of UIC's highest awards: Distinguished Researcher of the Year (2020), Inventor of the Year (2014), University Scholar (2013). He is also the recipient of several IEEE awards, U.S. ONR Young Investigator Award (2005) and U.S. NSF CAREER Award (2003). Currently, he is also a PELS AdCoM member and member at large and was the chair for PELS TC on Sustainable Energy Systems for six years.

Tobias Geyer recently joined ABB Medium-Voltage Drives in Switzerland as the R&D platform manager of the ACS6080. He is also an extraordinary professor at Stellenbosch University, South Africa. Geyer received the Dipl.-Ing. degree in electrical engineering, the Ph.D. in control engineering and the Habilitation degree in power electronics from ETH Zurich in the years 2000, 2005 and 2017, respectively.

He is the author of 35 patent families and the book "Model predictive control of high power converters and industrial drives" (Wiley, 2016). He teaches a regular course on model predictive control at ETH Zurich. His research interests include medium-voltage and low-voltage drives, utility-scale power converters, optimized pulse patterns and model predictive control.

Geyer received the Semikron Innovation Award and the Nagamori Award, both in 2021. He is also the recipient of the 2017 First Place Prize Paper Award in the Transactions on Power Electronics, the 2014 Third Place Prize Paper Award in the Transactions on Industry Applications, and of two Prize Paper Awards at conferences. He is a former associate editor for the Transactions on Industry Applications (from 2011 until 2014) and the Transactions on Power Electronics (from 2013 until 2019). He was an international program committee vice chair of the IFAC conference on Nonlinear Model Predictive Control in Madison, WI, USA, in 2018. Geyer is a fellow of the IEEE and a distinguished lecturer of the Power Electronics Society from the year 2020 until 2023.

Debanjan Chatterjee received the B.E. degree in electrical engineering from Jadavpur University, Kolkata, India, in 2015, and received his PhD in electrical and computer engineering at The University of Illinois Chicago (UIC), Chicago, IL, USA in 2021. He has been with ABB US Corporate Research Center (USCRC), Raleigh, since June 2021, where he is employed as a research scientist.

At USCRC, he is working on solid state circuit breakers and power converters for a variety of industry applications, including firmware development, gate driver design, and EMI/EMC analysis. His research interests encompass model predictive, switching sequence and switching transition controllers for wide-bandgap power electronic systems. He is a reviewer for IEEE Transactions on Power Electronics and IEEE Transactions on Industrial Electronics and serves as a technical committee member for top IEEE conferences.

T8(AM): Virtual Synchronous Machines - Inverters for a Stable and Well-damped Grid

Radu Bojoi received the M.Sc. degree from Technical University of Iasi, Romania, in 1993, and the Ph.D. degree from Politecnico di Torino, Torino, Italy, in 2002, all in electrical engineering. He is a full professor of power electronics and electrical drives with the Energy Department G. Ferraris and chairman of the Power Electronics Innovation Center, Politecnico di Torino.

Bojoi has authored or coauthored more than 150 papers covering electrical drives and power electronics for industrial applications, transportation electrification, power quality, and home appliances. He was involved in many research projects with industry for direct technology transfer aiming at obtaining new products. Bojoi is the co-recipient of five prize paper awards, the last one in 2015 as IEEE-IAS Prize Paper Award. He is teaching several courses in the area of power electronics and power systems, and has given tutorials in ICEM 2018, ECCE 2018 and IEMDC 2019.

Fabio Mandrile received the M.Sc. and Ph.D. degrees in electrical engineering from Politecnico di Torino, Italy, in 2017 and 2021, respectively. He is currently assistant professor at Dipartimento Energia G. Ferraris at Politecnico di Torino. His main research interests are virtual synchronous machines and power electronics for grid-connected applications, on which he focused his Ph.D. and current research activity.

George Weiss received the M.Eng. degree in control engineering from the Polytechnic Institute of Bucharest, Romania, in 1981, and the Ph.D. degree in applied mathematics from Weizmann Institute, Rehovot, Israel, in 1989. He was with Brown University, Providence, RI, USA; Virginia Tech, Blacksburg, VA, USA; Ben-Gurion University, Be'er Sheva, Israel; the University of Exeter, U.K.; and Imperial College London, U.K.

Weiss is leading research projects of the European Commission, the Israeli Ministry of Energy and the Israeli Electricity Company. His research interests include distributed parameter systems, operator semigroups, passive and conservative systems, power electronics, repetitive control, sampled data systems, and wind-driven power generators. He teaches courses from the general area of control theory, functional analysis and power electronics, and has given tutorials and plenary lectures at several conferences.

Florian Reissner received the B.Sc. and M.Sc. degrees from the Technical University of Berlin, Germany, in 2015. He is currently pursuing the Ph.D. degree with the Power Electronics for Renewable Energy Group, Tel Aviv University. From 2015 to 2020, he worked in project management with Vinci Energies, Lyon, and he was an Innovation Consultant and design thinking coach with incubators in Frankfurt and Berlin. In 2020, he started working as an early stage researcher (funded by the European Commission) at Tel Aviv University. His current research interests include control techniques in power systems and control theory.

T9(AM): Electric Propulsion: Challenges and Opportunities

Jin Wang (IEEE fellow) is a full professor at The Ohio State University. Wang has over 200 peer-reviewed journal and conference publications and nine patents. His research interests include wide-bandgap power devices and their applications, high-voltage and high-power converter/inverters, electrification of transportation and integration of renewable energy sources.

Wang initiated and served as the general chair for the 1st IEEE Workshop on Wide Bandgap Power Devices and Applications in 2013. Currently, Wang serves as the chair for the Technical Committee on Aerospace Power at the IEEE Power Electronics Society and an associate editor for IEEE Transactions on Power Electronics and IEEE Journal of Emerging and Selected Topics in Power Electronics (J-ESTPE).

Thomas M. Jahns (IEEE Fellow, NAE Member) is a Grainger professor of power electronics and electric machines at the University of Wisconsin–Madison. A member of the US National Academy of Engineering, Jahns is a recognized international authority on high-performance permanent magnet (PM) synchronous machines.

Before joining UW in 1998, Jahns worked 15 years for GE Corporate R&D (now GE Global Research) where he was a leading researcher on motor drives and power electronics, including leadership of a "more-electric aircraft" initiative to develop high-power-density power converters and machines for several demanding aerospace applications including integrated starter/alternators.

Bulent Sarlioglu is a Jean van Bladel associate professor with the University of Wisconsin-Madison and the associate director of the Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC). From 2000 to 2011, he was with Honeywell International's Aerospace Division, Torrance, CA, USA, most recently as a staff systems engineer. His expertise includes electrical machines, drives, and power electronics, with a particular emphasis on electrification of transportation and industrial applications.

Sarlioglu is the inventor or co-inventor of 20 U.S. patents and many international patents. In addition, he has more than 200 technical papers that are published in conference proceedings and journals. Sarlioglu was the recipient of the Honeywell's Outstanding Engineer Award in 2011 for his outstanding contribution to aerospace, the NSF CAREER Award in 2016, and the 4th Grand Nagamori Award from Nagamori Foundation, Japan, in 2018. Sarlioglu is the recipient of the IEEE PES Cyril Veniott Award in 2021. Sarlioglu became a fellow for the National Academy of Inverters in 2021 and IEEE Fellow in 2022.

Patrick McCluskey (Ph.D., materials science and engineering, Lehigh University, Bethlehem, PA) is a professor of mechanical engineering at the University of Maryland, College Park and the Division Leader for Electronic Products and Systems. He has over 20 years of research experience in the areas of thermal management, reliability, and packaging of electronic systems for use in extreme temperature environments and power applications. Applications have included wind turbines, hybrid electric vehicles, and aerospace generators. McCluskey has published three books and well over 100 peer reviewed technical articles.

John Kizito is an associate professor in mechanical engineering at North Carolina A&T State University in Greensboro with research portfolio in thermal management of electromechanical systems of the Air Force Research Lab (AFRL) in Dayton, Ohio. Kizito has numerous awards including membership to Translation to Space Exploration Systems Panel of the Decadal Survey on Space (National Academics of Science, Engineering and Medicine), NASA faculty fellow and four NASA team achievement awards from NASA Glenn Center in Ohio. Also, Kizito serves as the campus director for the NASA/NC Space Grant.

Julia Zhang is an associate professor at The Ohio State University. Zhang has three years' automotive industry experience with Ford Motor Company and is currently leading multiple projects on megawatt-level electric machines for electric propulsions. Her research interests include the design of high power density, high torque density ac electric machines for vehicle systems, robotic systems and renewable energy generation systems, modeling and control of ac electric machine drive systems.

T10 (AM): Solid-State Transformers – Fundamentals, Industrial Applications, Challenges

Johann W. Kolar (M'89–F'10) is a fellow of the IEEE, an International Member of the US NAE and a full professor and head of the Power Electronic Systems Laboratory at the Swiss Federal Institute of Technology (ETH) Zurich. He has proposed numerous novel converter concepts including the Vienna Rectifier, has spearheaded the development of x-million rpm motors and has pioneered fully automated multi-objective power electronics design procedures.

Kolar has graduated 80+ Ph.D. students, has published 900+ research papers, four book chapters, and has filed 200+ patents. He has served as IEEE PELS distinguished lecturer from 2012 to 2016. He has received 40+ IEEE Transactions and Conference Prize Paper Awards, the 2014 IEEE Power Electronics Society R. David Middlebrook Achievement Award, the 2016 IEEE PEMC Council Award, the 2016 IEEE William E. Newell Power Electronics Award, the 2021 EPE Outstanding Achievement Award and 2 ETH Zurich Golden Owl Awards for excellence in teaching.

The focus of his current research is on ultra-compact/efficient WBG PFC rectifier and inverter systems, ultra-high BW switch-mode power amplifiers, multi-port converters, solid-state transformers, multi-functional actuators, ultra-high speed/motor-integrated drives, bearingless motors, ANN-based multi-objective design optimization and sustainable systems.

Jonas Huber (S'11–M'16) received the MSc (with distinction) degree and the PhD degree from the Swiss Federal Institute of Technology (ETH) Zurich, Switzerland, in 2012 and 2016, respectively. Since 2012, he has been with the Power Electronic Systems Laboratory, ETH Zurich and became a post-doctoral fellow, focusing his research interests on the field of solid-state transformers, specifically on the analysis, optimization, and design of high-power multi-cell converter systems, reliability considerations, control strategies, and applicability aspects.

From 2017, he was with ABB Switzerland as an R&D engineer designing high-power dc-dc converter systems for traction applications, and later with a Swiss utility company as a business development manager. He then returned to the Power Electronic Systems Laboratory as a senior researcher in 2020, extending his research scope to all types of WBG-semiconductor-based ultra-compact, ultra-efficient or highly dynamic converter systems. Since 2015, he has co-presented nine tutorials at major IEEE conferences (e.g., ECCE, APEC).

T11(PM): Design and Control of Solid-State DC Transformers for DC Transmission and Distribution Grids

Rik W. De Doncker (F'01) received the Ph.D. degree in electrical engineering from the Katholieke Universiteit Leuven, Leuven, Belgium, in 1986. In 1987, he was appointed as a visiting associate professor at the University of Wisconsin, Madison. After a short stay as an adjunct researcher with Interuniversity Microelectronics Centre, Leuven, he joined, in 1989, the Corporate Research and Development Center, General Electric, Schenectady, NY.

In 1994, De Doncker joined Silicon Power, a former division of General Electric, as the vice president of technology. In 1996, he became a professor at RWTH Aachen University, Aachen, Germany, where he currently leads the Institute for Power Electronics and Electrical Drives. Since 2006, he has been the director of the E.ON Energy Research Center, RWTH Aachen University.

De Doncker was the president of the IEEE Power Electronics Society (PELS) in 2005 and 2006. He was the recipient of the IEEE IAS Outstanding Achievement Award in 2002, the IEEE PES Nari Hingorani Custom Power Award in 2008, the IEEE William E. Newell Power Electronics Award in 2013, and the IEEE Medal in Power Engineering in 2020. In 2010, he received an honorary PhD from TU Riga, Latvia.

Jingxin Hu (M'19) received the B.S. degree from Northeastern University, Shenyang, China, in 2010, and the M.Sc. degree and Dr.-Ing. degree both with the highest distinction (summa cum laude) from RWTH Aachen University, Aachen, Germany, in 2013 and 2019, all in electrical engineering. From April 2012 to October 2012, he was an intern research engineer at the ABB Corporate Research Center (ABB-CRC), Baden-Daettwil, Switzerland. From 2013 to 2014, he worked at the High Power Electronics Laboratory at General Electric Global Research Center (GE-GRC), Munich, Germany.

Since October 2014, he has been with the Institute for Power Generation and Storage System, E.ON Energy Research Center, RWTH Aachen University, Aachen, Germany, where he is currently working as a senior scientist to lead research projects. Hu was the recipient of Second Prize Paper Award of IEEE IPEC (ECCE Asia) in 2018 and the STAWAG Best Dissertation Prize of RWTH Aachen University in 2019. His main research interests include solid-state transformers, renewable power generation and dc distribution. Hu was a tutorial instructor in IEEE IPEMC 2020 ECCE-Asia, eGrid 2020 and ECCE 2021.

Shenghui Cui (M'19) received the B.S. degree from Tsinghua University, Beijing, China, in 2012, the M.S. degree from Seoul National University, Seoul, South Korea, in 2014, and the Dr.-Ing. degree with the highest distinction (summa cum laude) from RWTH Aachen University, Aachen, Germany, in 2019, all in electrical engineering. Since September 2021, Cui has been with Department of Electrical and Computer Engineering, Seoul National University, Seoul, South Korea as an assistant professor. From March 2015 to May 2021, he was with the Institute for Power Generation and Storage Systems, E.ON Energy Research Center, RWTH Aachen University, Aachen, Germany, where he worked as research associate and later on as senior scientist.

Cui's research interests include interaction of power systems and power converters, power converters in ac/dc utility applications, and applications of wide-bandgap power devices. Cui was the recipient of the STAWAG Best Dissertation Prize from the Faculty of Electrical Engineering and Information Technology, RWTH Aachen University in 2019, the Second Place Prize Paper Award of the IEEE Transactions on Power Electronics in 2018, the Second Prize Paper Award of IEEE IPEC (ECCE Asia) in 2018, and the Outstanding Presentation Award of the IEEE Applied Power Electronics Conference in 2014.

Subhashish Bhattacharya (F'22) received his B.E. from IIT Roorkee, India, M.E. from IISc, India, and Ph.D. from the University of Wisconsin-Madison, all in electrical engineering. He worked in the FACTS and Power Quality group at Westinghouse, which later became part of Siemens Power, from 1998 to 2005. He joined the

Department of ECE at NCSU in August 2005, where he is Duke Energy Distinguished Professor and a founding faculty member of NSF ERC FREEDM Systems Center, Advanced Transportation Energy Center [ATEC] and the U.S. DOE initiative on WBG based Manufacturing Innovation Institute – PowerAmerica - at NCSU.

Bhattacharya's research interests are solid-state transformers, integration of renewable energy resources, MV power converters enabled by HV SiC devices, FACTS, utility applications of power electronics and power quality issues; dc microgrids, high-frequency magnetics, active filters, and application of new power semiconductor devices such as SiC and GaN for converter topologies. His research is funded by several industries, NSF, DoE, ARPA-E, US Navy, ONR, NASA. He has over 600 publications and 10 patents with several pending patent applications.

T12(PM): Motor drive design and evaluation using multi-domain tool suite for faster development process

Albert Dunford received his undergraduate degree in applied science from UBC in 2007. He joined Powersim nine years ago and has been the primary technical contact ensuring user success for North American PSIM users ever since. He regularly hosts live webinars and generates tutorial videos on a wide range of topics covering the full spectrum of power converters and motor drives. Albert has worked closely with all customer types from graduate students to experienced designers in all industries to ensure that they can use the full depth of PSIM functionality for their simulation needs.

Before joining Powersim, he worked on industrial voltage regulators/conditioners and with an applied bio-physics spin-off company, Boreal Genomics. With Boreal, he designed the electronics for a novel DNA separation method. The method, SCODA, utilizes high voltage rotating fields and changing thermal gradients to separate DNA based on sequence with applications including cancer detection.

Sreeram Mohan received his undergraduate degree in Electronics and Telecommunications from India. His career spanning across 16 years started as a technical support engineer supporting heterogenous software-defined radio platforms involving DSP/FPGAs and serving in various roles spanning across quality engineering, software development and contributed to specialized toolboxes in model based development tools.

He also served as a consultant at TCS (Tata Consultancy Services) in research projects on applying Artificial Intelligence for Prognostics/Diagnostics for Aircrafts resulting also in generated patented work around DPHM (diagnostics prognostics health monitoring) in real-time systems. In the current stint he is serving as a vice president (engineering and product management for Altair's Math and Systems portfolio of model-based tools).

T13(PM): Electric Vehicle Batteries and Charging Systems: A Primer

Ashish Arora is a principal engineer at Exponent, an engineering and scientific consulting firm. Arora also has extensive experience with energy storage systems in the consumer products, aviation, automobile and utility industries. In addition to performing root cause analysis of battery system failures, he assists clients by performing design reviews and risk analyses of battery systems to evaluate the potential for field failure and safety issues.

Arora has also assisted his clients in evaluating and choosing battery vendors that can produce battery systems with the required quality and safety on an ongoing basis. He has authored numerous publications on Li-ion battery systems including a book on the subject of Li-ion Battery Failures in Consumer Electronics in 2019.

Rita Garrido Menacho is an associate at Exponent, an engineering and scientific consulting firm. Garrido Menacho has assisted clients on the failure analysis and safety design reviews of consumer products, energy storage systems, and automotive electronic systems. She has worked extensively on evaluating safety and the overall design quality of Li-ion batteries and battery pack protection circuitries. These evaluations include risk assessments, design failure modes analysis, and dedicated electrical and mechanical testing. Additionally, she has assisted in investigations involving automotive electronic system failures and recall-related matters.

T14(AM): Recent Advances on Modular-based Multilevel Voltage-Source Converter (VSC) for MV and HV applications: Principle, Control, and Its competitiveness with MMC

Dong Dong received the B.S. degree from Tsinghua University, Beijing, China, in 2007, and the M.S. and Ph.D. degrees from Virginia Tech, Blacksburg, VA, USA, in 2009 and 2012, both in electrical engineering.

From 2012 to 2018, he was with GE Global Research Center (GRC), Niskayuna, NY, USA, as an electrical engineer. At GE, he participated in and led multiple technology programs including MV/HVDC power distribution and power delivery, SiC high-frequency high-power conversion systems, solid-state transformers, and energy storage system. He received the GE gold medallion patent award and GE technology transition awards.

Since 2018, he has been with the Bradley Department of Electrical and Computer Engineering, Virginia Tech. He has published over 35 referred journal publications and more than 80 IEEE conference publications. He currently holds 29 granted U.S. patents. His research interests include wide-band-gap power semiconductor-based high frequency power conversion, soft-switching and resonant converters, high-frequency transformers, and MV and HV power conversion system for grid, renewable, and transportation applications.

Dong is currently an associate editor for IEEE Transactions on Power Electronics. He received two Prize Paper Awards from the IEEE Transactions On Power Electronics and IEEE Transactions On Industry Applications and William Portnoy Prize Paper Award from IEEE IAS. He served as the vice chair of IEEE Industry Application Society Schenectady Region Chapter in 2017 and general chair of IEEE International Conference on DC Microgrids in 2021.

Di Zhang received the B.S. and M.S. degrees from Tsinghua University, Beijing, China, in 2004 and 2006, respectively, and the Ph.D. degree from Virginia Tech, Blacksburg, VA, USA, in 2010, all in electrical engineering. He is currently an associate professor with Naval Postgraduate School, Monterey, CA, USA. His research interests include the modeling and design of medium- to high-voltage power converters, SiC-based high-performance power conversion, and power conversion system for grid, renewable, and aviation.

T15(PM): Best Practices for Low-Power (IoT/IIoT) Designs: Separating the Source-Side & Load-Side Analyses

Brian Zahnstecher is a Sr. member of the IEEE, chair (emeritus) of the IEEE SFBAC Power Electronics Society (PELS), IEEE PELS North America Regional (R1-3) chair, sits on the Power Sources Manufacturers Association (PSMA) board of directors, is co-founder & co-chair of the PSMA Reliability Committee, co-chair of the PSMA Energy Harvesting Committee, and is the principal of PowerRox, where he focuses on power design, integration, system applications, OEM market penetration, market research/analysis, and private seminars for power electronics.

Zahnstecher co-chairs the IEEE Future Directions (formerly 5G) initiative webinar series and is the founding co-chair of the IEEE 5G Roadmap Energy Efficiency Working Group and has lectured on this topic at major industry conferences. He previously held positions in power electronics with industry leaders Emerson Network Power (now Advanced Energy), Cisco, and Hewlett-Packard. He has been a regular contributor to the industry as an invited keynote speaker, author, workshop participant, session host, roundtable moderator, and volunteer. He has nearly 20 years of industry experience and holds master and bachelor degrees from Worcester Polytechnic Institute.

T16(PM): Design Strategies for High-Power, High-Current, Isolated DC-DC Converters using Soft-Switching Technology and Silicon Carbide Transistors

Mark J. Scott received his B.S., M.S., and Ph.D. degrees in electrical and computer engineering from The Ohio State University in 2005, 2013, and 2015, respectively. His work experience includes developing and installing industrial automation systems and validating power electronics for automotive applications. Currently, he is an assistant professor at Miami University in Oxford, Ohio, USA.

Scott researches the design trade-offs of using silicon carbide (SiC) and gallium nitride (GaN) power devices in isolated dc-dc converters and active rectifiers used in electrified transportation. He also explores prognostic and health management techniques for power conversion hardware.

Alexander Isurin received an M.S. in Electrical Engineering from the University of Electrical Communication in St. Petersburg, Russia. His design experience includes electronic welding devices, charging for electric vehicles, and custom industrial power supplies at high power levels. He is the author of numerous patents for power conversion topologies, control of power conversion hardware, and semiconductor gate drive design strategies. His technology has been and continues to be implemented into automotive applications. His current research interests include high-frequency power conversion using soft switch technology, with an emphasis on cost-effectiveness and high efficiency.

T17(PM): Emerging Cybersecurity Challenges in Modern Energy Systems – Assessment and Solutions

Subham Sahoo received his Ph.D. degree in electrical engineering at Indian Institute of Technology (IIT), Delhi, New Delhi, India in 2018. After the completion of his PhD, he worked as a postdoctoral researcher in the Department of Electrical and Computer Engineering in National University of Singapore during 2018-19 and in Aalborg University (AAU), Denmark during 2019-2020. He is currently an assistant professor in the Department of Energy, AAU, Denmark.

Sahoo is a recipient of the Indian National Academy of Engineering (INAE) Innovative Students Project Award for the best PhD thesis across all the institutes in India for the year 2019. He was also a distinguished reviewer for IEEE Transactions on Smart Grid in the year 2020. He is an active contributor and chairs the cybersecurity working group in the IEEE PELS Technical Committee (TC 10) on Design Methodologies. He has delivered two tutorials in IEEE APEC 2020 and IEEE IECON 2020. He has also organized the first Industrial/PhD course on cybersecurity for power electronic systems in AAU in the year 2020.

His research interests are control, optimization, cybersecurity and stability of power electronic dominated grids, physics-informed machine learning tools for power electronic systems.

Yan Li received her Ph.D. degree from the University of Connecticut, Storrs, CT, U.S., in 2019. She also received a Ph.D. degree from Tianjin University, Tianjin, China, in 2013. Both are in electrical engineering. She worked as a postdoctoral researcher in the Department of Electrical Engineering and Computer Science in University of Denver during 2013-2014. She is currently an assistant professor at the School of Electrical Engineering and Computer Science in The Pennsylvania State University, University Park, PA, U.S.

Li is a recipient of IEEE-PES Outstanding Engineer Award, Connecticut Women of Innovation Award, UConn Outstanding Senior Women Academic Achievement Award, Connecticut Power and Energy Society Rising Star Award. She is an associate editor of IET Energy System Integration and an active reviewer for several journal and conferences, including IEEE Transactions on Power System, IEEE PES General Meeting, and IEEE ITEC.

She is a senior member of IEEE and a member of INFORM. She has developed a Sustainable Energy course for Penn State undergraduate students, which introduces typical renewable energy, control strategies, and microgrids. A new course, Cyber-Physical Microgrids, is under development. Her research interests include cyber-physical microgrids, quantum computing, data-driven modeling and control, cybersecurity, software-defined networking, resilience analysis, etc.

Charalambos Konstantinou is an assistant professor of computer science (CS) and affiliate professor of electrical and computer engineering (ECE) at King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia. He is the PI of the Secure Next Generation Resilient Systems Lab and a member of the Resilient Computing and Cybersecurity Center (RC3) at KAUST. His research interests are in secure, trustworthy, and resilient cyber-physical and embedded IoT systems. He is also interested in critical infrastructures security and resilience, renewable energy integration, and real-time simulation.

Konstantinou received a Ph.D. in EE from New York University and an M.Eng. degree in ECE from National Technical University of Athens, Greece. Before joining KAUST in 2021, he was an assistant professor at Florida State University. Konstantinou is currently the chair of the IEEE Task Force on Resilient and Secure Large-Scale Energy Internet Systems and the co-chair of the IEEE Task Force on Cyber-Physical Interdependence for Power System Operation and Control. He has delivered a recent tutorial on 'Industrial Control Systems Security' in Design, Automation, and Test in Europe (DATE) Conference and Exhibition 2021. He is a senior member of IEEE, a member of ACM, and an ACM Distinguished Speaker (2021-2024).

T18(AM): Advanced power conversion systems for next-generation wireless battery charging

Deepak Ronanki (S'01–SM'13) received his Ph.D. degree in electrical and computer engineering at the University of Ontario Institute of Technology, Oshawa, Canada in 2019. He worked as a post-doctoral fellow at the University of Windsor in 2020. From 2012 to 2016, he was a power converters design engineer with Electronics Division, Bharat Heavy Electricals, Bengaluru, India. He is currently working as an assistant professor at the Indian Institute of Technology Roorkee, India since 2020.

He received the Best 3-min Ph.D. Thesis Award from IEEE Transportation Electrification Community in 2021, the Outstanding Doctoral Thesis Award from the University of Ontario Institute of Technology in 2020 and the Outstanding Reviewer Award for the year 2019 from the IEEE Transactions on Power Electronics in 2020. He has published more than 50 peer-reviewed technical papers, and five book chapters.

He is currently serving as an associate editor for IEEE Transactions on Industry Applications, IEEE Transactions on Transportation Electrification and Transportation Electrification Community (TEC) eNews Letter. His current research interests include power conversion systems for renewable energy, electric vehicle power trains, electric vehicle charging infrastructure, electric energy storage systems, and transportation electrification.

Sheldon S. Williamson (S'01–M'06–SM'13–F'20) received his bachelors of engineering (B.E.) degree in electrical engineering with high distinction from the University of Mumbai, Mumbai, India, in 1999. He received the masters of science (M.S.) degree in 2002, and the doctor of philosophy (Ph.D.) degree (with honors) in 2006, both in electrical engineering, from the Illinois Institute of Technology, Chicago, IL, specializing in automotive power electronics and motor drives, at the Grainger Power Electronics and Motor Drives Laboratory.

Currently, Williamson is a professor at the Smart Transportation Electrification and Energy Research (STEER) group, within the Department of Electrical, Computer, and Software Engineering, at Ontario Tech University, in Oshawa, Ontario, Canada. He also holds the prestigious NSERC Canada Research chair position in Electric Energy Storage Systems for Transportation Electrification. His main research interests include advanced power electronics and motor drives for transportation electrification, electric energy storage systems, and electric propulsion. Williamson is a fellow of the IEEE.

Mauricio Esguerra was born in Bogotá and holds a degree in physics from TU München and Ohio State University. He has more than 26 years of experience in the field of soft magnetic materials and applications, modeling, testing, inductive components, power electronics and LED lighting. He held various positions at various companies including Siemens, EPCOS, Dialight, Pulse, Falco and Eglo and is an active member of IEC standard committees. Esguerra holds fourteen patents and has published over 70 papers and is CEO and co-founder of MAGMENT.

T19(AM): Advanced Magnetic Designs Enabling Electrification of High Power Industrial Systems

Paul R. Ohodnicki is an associate professor in the Department of Mechanical Engineering and Materials Science at the University of Pittsburgh. He received his Ph.D. in materials science and engineering from Carnegie Mellon University in 2008, after which he joined PPG Industries R&D working on thin-film coating materials and earned the Advanced Manufacturing and Materials Innovation Award from Carnegie Science Center in 2012.

Ohodnicki later continued his career at the DOE National Energy Technology Laboratory (NETL), where he eventually served as a technical portfolio lead guiding teams of materials scientists working on the development of optical and microwave sensors as well as magnetic materials and power electronics development for high-frequency transformer based solar PV/energy storage inverters.

He is the recipient of the 2016 Presidential Early Career Award for Scientists and Engineers, the highest honor the federal government can bestow on early-career scientists or engineers. Before joining the University of Pittsburgh as an associate professor, Ohodnicki received the 2019 R&D 100 Award owing to his work on cobalt-rich metal amorphous nanocrystalline alloys for permeability-engineering gapless inductors.

Brandon Grainger is currently an Eaton faculty fellow, an assistant professor, and associate director of the Energy GRID Institute and Electric Power Engineering program in the Department of Electrical and Computer Engineering at the University of Pittsburgh (Pitt), Swanson School of Engineering. He holds a PhD in electrical engineering with a specialization in power conversion. He also obtained his master's degree in electrical engineering and bachelor's degree in mechanical engineering (with minor in electrical engineering) all from Pitt.

Grainger was also one of the first original R.K. Mellon graduate student fellows through the Center for Energy at Pitt. His research interests are in electric power conversion, medium- to high-voltage power electronics (HVDC and STATCOM), general power electronic converter design (topology, controller design, magnetics), resonant converters and high power density design, power semiconductor evaluation (SiC and GaN) and reliability assessment, aerospace power conversion systems, electric vehicle motor drives, and solid state transformer design.

Grainger has either worked or interned for ABB Corporate Research, ANSYS, Mitsubishi Electric, Siemens and Industry, and has regularly volunteered at Eaton's Power Systems Experience Center. In his career thus far, he has contributed to 80+ articles, 1 issued patent, and editor of one research textbook. Grainger is a senior member of the IEEE.

Richard Byron Beddingfield received his BS EE and MS PE in electric power systems engineering from North Carolina State University in 2014 and 2015 respectively. He completed his PhD in high power medium frequency magnetics for power converter applications in 2018. His research focus is on magnetic material drive power converter designs and novel applications of magnetic materials. Beddingfield has contributed to the converter designs leveraging high temperature magnetics and strain induced anisotropy magnetic ribbon materials. He has also developed methods for high power, contactless, power transformers and arc-free interconnects as well as variable inductors for dc circuit breakers.

Subhashish Bhattacharya is a professor, founding faculty member, and co-PI of NSF ERC FREEDM systems center and DOE initiative on WBG based Manufacturing Innovation Institute – PowerAmerica at NCSU. He has authored over 600 peer-reviewed technical articles, two book chapters, and has 10 issued patents to his credit. His research interests are solid-state transformers, MV power converters, FACTS, utility applications of power electronics and power quality issues; high-frequency magnetics, active filters, and application of new power semiconductor devices such as SiC for converter topologies.

T20(PM): Pulse energy modulation v.s. pulse width modulation for single-phase power inverters with power decoupling technologies

Shuang Xu received the B. Sc. E.E. in 2012 from Hefei University of Technology, Hefei, China, and the Ph.D. in electrical engineering in 2018 at the University of New Brunswick (UNB), Fredericton, Canada. He is currently a post-doctoral associate at the Western University, London, Canada, and a Guesting associate professor at the North China University of Technology, Beijing, China. From 2018 to 2020, he was a post-doctoral fellow at the Emera and NB Power Research Centre for Smart Grid Technologies at UNB. His research interests include renewable energy systems, energy storage technologies, multiple microgrids, power electronics, and power system support functions for distributed energy resources.

Xu was a recipient of the IEEE Applied Power Electronics Conference Outstanding Presentation Award in 2017. He was the tutorial speaker of the IEEE International Symposium on Power Electronics for Distributed Generation Systems (PEDG 2019) and the IEEE International Conference on High Voltage Direct Current (HVDC 2020).

In addition, he has been teaching college physics in The Princeton Review (TPR) from 2015 to 2019, where he got the year-end teaching evaluation of 5.0/5.0 in 2016 (<3% in Canada), featured in the TPR Newsletter in Feb. 2017, and obtained the Instructor Bonus Earner of TPR North America in July 2017. He was also the session chair of PEDG 2019. He serves as the chair in 2019 and the vice chair in 2020 of IEEE UNB Power Electronics Society Student Branch Chapter.

Meiqin Mao (M'08-SM'14) received the B.Sc., M.Sc. and Ph.D. degrees in electrical engineering from Hefei University of Technology (HFUT) in 1983, 1988 and 2004 respectively. She is a professor with the School of Electrical and Automation Engineering, HFUT, China. Her research interests and expertise include renewable energy generation technology, distributed power generation and microgrids, power electronics applied in power systems. She has published more than 190 papers. She serves as an associate editor for IEEE Journal of

Emerging and Selected Topics in Power Electronics and the Committee Member of IEEE William E. Newell Power Electronics Award (2016-2018).

Liuchen Chang received B.S.E.E. from Northern Jiaotong University in 1982, M.Sc. from China Academy of Railway Sciences in 1984, and Ph.D. from Queen' University in 1991. He joined the University of New Brunswick in 1992 and is a professor emeritus at UNB. He was the NSERC chair in Environmental Design Engineering from 2001 to 2007, and the principal investigator of Canadian Wind Energy Strategic Network (WESNet) from 2008 to 2014. Chang is president of the IEEE Power Electronics Society (2021-2022).

Chang was a recipient of the CanWEA R.J. Templin Award in 2010, the Innovation Award for Excellence in Applied Research in New Brunswick in 2016, and the PELS Sustainable Energy Systems Technical Achievement Award in 2018. He is a fellow of the Canadian Academy of Engineering (FCAE) and has published more than 370 refereed papers in journals and conference proceedings. Chang has focused on research, development, demonstration and deployment of renewable energy based distributed energy systems and direct load control systems.

T21(AM): Extend the lifespan of electric vehicle batteries in their second life for renewable and smart energy grids

Chris Mi is the distinguished professor and chair of the Department of Electrical and Computer Engineering at San Diego State University. He is a fellow of both the IEEE and the SAE. He was previously a faculty member at the University of Michigan-Dearborn from 2001 to 2015, and an electrical engineer with General Electric from 2000 to 2001. He also served as the CTO of 1Power Solutions from 2008 to 2011.

Mi has won numerous awards, including the "Distinguished Teaching Award" and "Distinguished Research Award" from the University of Michigan-Dearborn, IEEE Region 4 "Outstanding Engineer Award," IEEE Southeastern Michigan Section "Outstanding Professional Award," and SAE "Environmental Excellence in Transportation (E2T) Award." He is the recipient of three Best Paper Awards from IEEE Transactions on Power Electronics. In 2019, he received the Inaugural IEEE Power Electronics Emerging Technology Award. Mi is the 2022 recipient of the Albert W. Johnson Research Lectureship and distinguished professor, SDSU's highest research honor.

Mi has published five books, 204 journal papers, 126 conference papers, and 25 issued and pending patents. He served as editor-in-chief, area editor, guest editor, and associate editor of multiple IEEE Transactions and served as the general chair of over ten IEEE international conferences.

T22(PM): The benefits of infrared thermography testing for the thermal management in energy storage and conversion

No instructor bio is available at this time.

T23(PM): Factors influencing active torque ripple cancellation in PMSM/IPMSM drives

Ramakrishnan Raja (M'11) received a B.Sc. degree from Amrita Institute of technology, India in 2003 and a master's degree in electrical engineering from New Jersey Institute of Technology, in 2005. He received his Ph.D. degree in automotive system engineering from University of Michigan-Dearborn, MI.

From 2004-2013 he worked for Delphi steering and Nexteer automotive as a senior electrical engineer. Currently he is working at Halla Mechatronics as chief scientist-controls. In addition, has been an associate professor in Saginaw Valley State University.

Raja is responsible for motor drive /vehicle dynamics control for various automotive applications. His research interests include electrical machines and variable speed drives including sensorless motor control drives. He is presently the associate editor for the Industrial Drives Committee and the Transportation System Committee.

T24(AM): Power HIL: Enabling Flexible and Repeatable Testing of Power Electronics Systems in Close-to-reality Environment

No instructor bios are available at this time.