TUTORIALS

Tutorials will be held on Sunday, September 23. Pre-registration for each tutorial is required. Please visit the Registration Desk for space availability.

Sunday, September 23 **8:00AM – 11:45AM**

AM Tutorials

Chair: Po-tai Cheng

AM1 | High Power/Voltage Power Converters and Applications – Opportunities and Challenges Offered by HV SiC Power Devices

Room B113

Instructors: Subhashish Bhattacharya; Richard Byron Beddingfield

The opportunities for HV SiC devices for MV and high power converters and utility applications and the challenges to apply HV SiC devices successfully will be presented in-depth for SiC 1200V to 1700V MOSFETs, and SiC 10 kV – 15 kV MOSFETs, JBS diodes, and 15 kV SiC IGBTs. The potential and challenges of the SiC 10-15 kV devices to enable MV power conversion systems, including MV motor drives, FACTS and MVDC grids will be explored with demonstrated application examples of SST, MV SiC power converters for grid tied solar applications, MV motor drives, and MV DC grids. Magnetics for High Power Converters with the latest advances in magnetic material qualification and characterization will be discussed.

AM2 | From the Solid-State-Transformer (SST) to the Smart Transformer?

Room B111

Instructors: Marco Liserre; Giampaolo Buticchi; Dr. Markus Andresen; Dr. Giovanni De Carne

The increasing connection of renewables and new loads is challenging the distribution grids. The Smart Transformer (ST), a power electronics-based transformer, can provide ancillary services to the distribution grids to support the grid management, in addition to the voltage adaptation. The Smart Transformer is a natural connection point for hybrid (AC and DC) grids both at MV and LV levels. In the tutorial the Smart Transformer is defined and the topologies and controllers are explored. Current challenges in hybrid grids are presented and proposed solutions are described. New services enabled with the Smart Transformer technology, for instance load sensitivity evaluation in LV grids and voltage and frequency regulation in MV/HV grids are explained. Reliability aspects of the Smart Transformer are reviewed and active measures to increase it and to enable prognostic maintenance are discussed.

AM3 | Hybrid AC/DC Microgrids: Configuration, Power Management and Converter Control

Room B115

Instructors: Yunwei (Ryan) Li; Kai Sun; Farzam Nejabtkhah

During the past decade, hybrid AC/DC microgrids have gained significant progress. In this tutorial, a panoramic introduction of hybrid AC/DC microgrids will be given first. Power management strategies will be discussed. Effective solutions to deal with the challenges due to high penetration integration of renewable generation in a hybrid AC/DC microgrid will be presented, which include power converter structures and coordination control between renewable generation and energy storage. Moreover, power quality control is one of the most critical operation aspects. Strategies to explore the potential of interfacing converters in a hybrid AC/DC microgrid to control the power quality (such as unbalance and harmonics) will be presented.

AM4 | Control for Grid-Friendly Power Converter Systems

Room B112

Instructors: Frede Blaabjerg; Yongheng Yang; Yi Tang

This tutorial is intended to introduce the recent advancements of grid-friendly power converter systems and their associated control techniques. The tutorial will start with the discussion of flexible active power control for renewable generation systems, which can limit the power ramp rate and reserve part of the active power for power system frequency regulation. The tutorial will then review the basic concept of power system inertia and discuss the challenges caused by the high penetration of renewables in modern and future power systems. The last part of the tutorial will present several emerging virtual inertia techniques enabled by power electronics.

AM5 | Photo-Electro-Thermal-Theory for LED Systems and its Applications

Room B117

Instructors: Ron Hui; Siew-Chong Tan

Light science of light-emitting diodes (LED) is a complex discipline involving highly nonlinear interactions of four elements (namely light, heat, power and color). The Photo-Electro-Thermal (PET) Theory is the system theory that unifies the interactions of these four elements under one mathematical framework. The PET Theory has the steady and dynamic forms that can now be used as a general design tool for LED system design and optimization. This tutorial will cover the basic theory and its applications. This is the first time this tutorial is made available to the professional community. This tutorial suits both researchers and professional engineers in lighting technology.

AM6 | Power Converters for Energy Storage Applications – Analysis and Design from Theory to Practice

Room B116
Instructor: Dr. Petar J. Grbović

Power electronics play significant role the modern civilization. The demand for energy storage technologies grows dramatically in recent years, so do the power electronics needed to integrate various energy storage technologies. This tutorial starts with a review of state of the art energy storage devices, their applications, design and sizing. Later, we will discuss in deep details interface power converters, including their topologies, multi-cell and multi-level converters, isolated and non-isolated converters, full and partial power rated converters, and etc. Control strategies of different concepts will also be presented with several case studies and design.

AM7 | Optimization Techniques for Solar Power Plants

Room B110
Instructors: Martin Ordonez; Emanuel Serban; Francisco Paz

Solar power installations are extremely sensitive to cost, payback time, and the availability of energy over time. Many factors must be weighed in the design of PV systems, including the number of panels, array configuration, and inverter selection. However, traditional design rules are too simplistic and do not make use of critical real-life information. Often, oversized components are used that do not produce any advantages for the PV system. This tutorial will present techniques aimed for the optimization of the PV systems, from the hardware components to the energy extraction strategies.

AM8 | Predictive Control – A Simple and Powerful Method of Control Power Converters and Drives

Room B114
Instructors: Ralph M. Kennel; José Rodríguez; Zhenbin Zhang

Until today the control of electrical power using power converters has been based on the principle of mean value, using pulse width modulation (PWM) with linear controllers in a cascaded structure. Recent research works have demonstrated that it is possible to use Predictive Control to control electrical energy with the use of power converters, without using any modulators and linear controllers. This is a new approach that will have a strong impact on control in power electronics in coming decades. The main advantages are: – Concepts are very intuitive and easy to understand. – Simple consideration of non-linearities in the model.

AM9-1 | Permanent Magnet Fundamentals

Room B119
Instructor: Stan Trout

Starting with the simple things we learned about magnets in the first grade, this seminar will present the basics of permanent magnets and magnetic materials more broadly. Attendees will understand the definitions, parameters and arcane units of magnetism, both CGS and SI. They will learn how magnets are processed, magnetized, characterized and affected by temperature. This small investment of your time will increase your magnet "IQ" and make this complex technology easier to navigate.

AM9-2 | Sequence Impedance Modeling and Analysis of Wind and PV Inverters Considering Coupling over Frequency

Room B119
Instructor: Jian Sun

This tutorial presents a systematic study of the small-signal responses of grid converters, and a practical method to account for it in system impedance analysis. After a brief review of the small-signal sequence impedance theory, we identify all nonlinearities in the inverter and control that contribute to such coupling, and examine its mechanism. Analytical models are presented to characterize the coupled current response and the mechanism between the coupling and inverter-grid system stability. This leads to a simple method to account for the coupling in impedance-based system analysis. Extension of this model to complex wind and PV farms is also presented. The tutorial concludes with a theory that explains how system resonance creates sustained harmonics, which is often observed in practice.

AM10 | High Voltage Rotating Machines-Design and Diagnostics

Room B118
Instructor: Mladen Sasic

Condition diagnostics of complex systems, such as high voltage rotating machines was never a simple task. Design requirements, use of different materials and demanding operating conditions require multiple off line tests and on line monitors to get information on machine condition. However, some tests just provide simple measurement results, without high diagnostic value. Basics of High Voltage motors and generators design and available on-line monitors and off-line tests will be explained.

Sunday, September 23 **12:30PM – 4:15PM**

PM Tutorials

PM1 | Application of Silicon-Carbide (SiC) Power Devices and Converters: Opportunities, Challenges and Potential Solutions

Room B113

Instructors: Xibo Yuan; Alex Q. Huang; Dr. Xu She

This tutorial will review the performance of state-of-the-art SiC devices and converters. While the opportunities in performance improvement with SiC devices are clear, there are also significant design challenges relating to high speed, high voltage and high temperature operation. These challenges will be analyzed and several solutions aiming to fully exploit the superior characteristics of SiC devices will be given. Several design examples such as high-density power converters based on SiC MOSFETs, high temperature converters with SiC BJTs and high voltage SiC converters for solid state transformer applications will be given to demonstrate the opportunities, design challenges and proposed solutions.

PM2 | Harmonic Modeling and Stability of Power Electronic Based Power Systems

Room B111

Instructors: Xionfei Wang; Frede Blaabjerg

The legacy power grids that are dynamically dominated by electrical machines are evolving as power electronic based power systems. The wide timescale control dynamics of converters tend to interact at different levels, leading to the harmonic instability in the form of resonances or abnormal harmonics. A number of incidents have been reported recently with the grid integration of large-scale renewable power plants and high-speed trains. This tutorial intends to provide a systematic discussion on the harmonic stability of power electronic based power systems, ranging from the basic concept, modeling and analysis methods, to active damping techniques.

PM3 | Electrical Drives Measurements and Testing: Past, Present, and Future

Room B115

Instructors: Eric Armando; Aldo Boglietti; Radu Bojoi

The tutorial is addressed to industry research and development centers and academia. The tutorial presents an overview concerning what to measure and how to measure electrical and mechanical quantities in electrical drives. The measurement procedures using power-meters and data-recorders along with sensors for electrical and mechanical quantities, will be discussed in detail. The right use of the measured values for the determination of induction and synchronous motor parameters and the efficiency will be focused with the aims at defining advanced testing methods of AC machines under inverter supply. The discussed approaches lead to significant reductions of the testing time and the results of the tests allows a completely characterization of the AC machines in terms of efficiency, losses, flux linkage maps, inductance maps, and Maximum Torque Per Ampere (MTPA) and Maximum Torque Per Volt (MTPV) profiles. The tutorial will include testing results for different machines including Induction motors IM), Surface Mount (SM) PM machines, Internal Permanent Magnet (IPM) machines and Synchronous Reluctance (SynchRel) machines.

PM4 | Condition Monitoring, Diagnostics and PHM of Electric Machine and Drive Systems

Room B112

Instructor: Pinjia Zhang, PhD

The application of electric machine and drive systems has been growing dramatically in the past few decades. It is critical to develop monitoring, prognostics and health management technology for electric machine and drive systems to proactively prevent sudden malfunction or failure. This tutorial provides an overview of monitoring, diagnostics, prognostics and health management technology for electric machine and drive systems. The tutorial will cover the following topics: 1. Typical failure modes of electric machine and drive systems; 2. Offline testing technique for machine and drive systems; 3. Online monitoring technique for machine and drive systems; 4. Prognostics technique for machine and drive systems.

PM5 | Power Electronics Enabled Technologies in Power Systems Connecting Utilities and Customers

Room B117

Instructors: Iqbal Husain; Srdjan Lukic; M. A. Awal; Hui Yu

This tutorial covers the components and devices, system architectures and controls, ancillary services and grid support, and customer interactions and benefits in the context of microgrids and networked power electronics based systems. This tutorial is organized into four parts: Part I provides a review of basic power electronics components in a modern power system; Part II presents system architecture, stability issues, primary and secondary control, grid synchronization techniques, and interconnection standards for DERs; Part III covers enabling communication technologies; and Part IV presents few case studies both at the residential and utility scale, finally concluding with trends into the future for widespread industrial adoption.

PM6 | Advanced Digital Current Regulation Strategies for Grid Connected Inverters

Room B116

Instructors: Grahame Holmes; Brendan McGrath

The basic concept of inverter current regulation is simple – minimize the error between a target reference and the actual measured current. However, achieving this goal in practice is very challenging. This tutorial presents state-of-the-art concepts for current regulation of grid connected inverters, looking at linear regulator gain constraints, the challenges of grid connected inverter current regulation with LCL filters, how to design a current regulator in the sampled z-domain space while managing modulation saturation, and how to accommodate common mode EMI. The tutorial will conclude by considering current regulation with grid harmonics, unbalanced grid voltages and high impedance grid networks.

PM7 | Modeling and System Design of Solid-State Lighting Drivers

Room B110

Instructors: Ray-Lee Lin

This tutorial explores the modeling and system design of solid-state lighting drivers. The multi-branch linear-model and the Taylor-series expression-based model are introduced to describe the V-I characteristic curves of the solid-state light sources. According to four parameters in datasheets, the voltage-controlled piece-wise linear-model can be built for circuit simulation work. The DC and AC equivalent circuit models of LEDs and LED arrays can be derived. The models of CCM single-loop control, CCM dual-loop and DCM dual-loop LED Drivers are developed to determine the optimal LED-array combinations. The Bode graphical approach is used for the compensator design.

PM8 | Battery Management Systems for Lithium-ion Batteries

Room B114

Instructors: Daniel-Ioan Stroe, PhD; Macieej Swierczynski, PhD

The objective of this tutorial is to provide the audience with an extensive overview of the Li-ion battery energy storage technology, its operating principles, advantages/drawbacks and performance behavior. As many BMS diagnostic algorithms are based on battery performance models, a deep understanding regarding the dependence of the battery performance parameters on various factors such as, temperature, load current, or number of cycles will be provided. The second part of the tutorial will focus on the BMS and their most important roles: charge/discharge management, battery cell balancing, and monitoring to ensure safety protection. Because BMSs are continuously developing, they will have new functionalities such as battery SOC and SOH estimation and they will be used for diagnostics purposes. Thus, different methods for battery SOC and SOH estimation will be discussed.

PM9-1 | Design, Modelling and Control of Linear Induction Motors (LIM) for Industrial Applications

Room B119

Instructors: Wei Xu; Marcello Pucci; Ion Boldea

With the ability to generate direct thrust without any mechanical transmission, the linear machines serve as excellent choice for industrial applications requiring linear motion, such as linear metros, MAGLEVs (see the people transfer system to/from Pudongh Airport in Shanghai at maximum 400Km/h), servo systems, conveyors, wave-energy generators, series hybrid-electric car generators small compressors, Stirling engine generators, fast action solenoids, loudspeakers, microphones, printers etc. Due to the special characteristics of linear machines, e.g., the cut-open magnetic circuit, the large air-gap length, the half-filled end slots, the end-effects, engineers face massive challenges in both design techniques and control strategies for high performance linear machines, drives, MAGLEVs, and so on. This tutorial aims to present the latest theoretical and technological ideas regarding the linear induction motors (LIM), with specific regard to: design techniques, dynamic modeling including end effects, parameters estimation techniques, electrical losses minimization techniques (ELMTs), linear and non-linear control techniques, and sensorless techniques.

PM9-2 | Lose Your Bearings: An Introduction to Magnetically Suspended Shafts

Room B119

Instructors: Eric Severson; Akira Chiba; Wolfgang Gruber; Rafal Jastrzebski

The goal of this tutorial is to train participants on how to use magnetic suspension in their motor systems in place of conventional bearings. Participants will analyze the shortcomings of conventional bearings, explore basic principles of magnetic forces, identify control techniques of magnetic bearings and bearingless motors, examine magnetic suspension technology for a broad range of power and speed motor systems, and investigate the history of and exciting new trends in research on bearingless motors. Ultimately, participants will evaluate the potential for magnetic suspension technology to disrupt their product development or research field.

PM10 | Interpretation of IEEE 519-2014 for Industrial and Commercial Applications

Room B118

Instructors: Mahesh M. Swamy

Minimizing harmonics will minimize inefficient operation of electrical equipment, reduce heat in electrical apparatus that carry power to rectifier loads, and minimize interference with sensitive loads, thereby reducing costly downtime and improving the life of electrical equipment. However, there is confusion in the Industrial and Commercial world as to which IEEE 519 document should one refer to in order to establish rough guidelines regarding voltage and current harmonics, since there are two versions of the IEEE 519 circulating in the drives application world. They are: a. IEEE 519-1992 and IEEE 519-2014. This tutorial is geared to show the significant difference between the old and new standard and will also bring out the presenters interpretation of the new standard as it applies to different applications.