# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>3</td>
</tr>
<tr>
<td>Partners</td>
<td>4</td>
</tr>
<tr>
<td>General Information</td>
<td>5</td>
</tr>
<tr>
<td>IEMDC 2019 Organizing Committee</td>
<td>6</td>
</tr>
<tr>
<td>Schedule-at-a-Glance</td>
<td>8</td>
</tr>
<tr>
<td>Sunday Tutorials</td>
<td>10</td>
</tr>
<tr>
<td>Morning Tutorials</td>
<td>10</td>
</tr>
<tr>
<td>Afternoon Tutorials</td>
<td>11</td>
</tr>
<tr>
<td>Monday Sessions</td>
<td>14</td>
</tr>
<tr>
<td>Plenary Sessions</td>
<td>14</td>
</tr>
<tr>
<td>Oral Sessions</td>
<td>14</td>
</tr>
<tr>
<td>Industry Session</td>
<td>21</td>
</tr>
<tr>
<td>Tuesday Sessions</td>
<td>22</td>
</tr>
<tr>
<td>Plenary Session</td>
<td>22</td>
</tr>
<tr>
<td>Oral Sessions</td>
<td>22</td>
</tr>
<tr>
<td>Poster Sessions</td>
<td>28</td>
</tr>
<tr>
<td>Industry Session</td>
<td>32</td>
</tr>
<tr>
<td>Wednesday Sessions</td>
<td>33</td>
</tr>
<tr>
<td>Plenary Session</td>
<td>33</td>
</tr>
<tr>
<td>Oral Sessions</td>
<td>33</td>
</tr>
<tr>
<td>Poster Sessions</td>
<td>37</td>
</tr>
<tr>
<td>Exhibitor Listing</td>
<td>44</td>
</tr>
<tr>
<td>Exposition Floor Plan</td>
<td>47</td>
</tr>
<tr>
<td>Westin Gaslamp Quarter Floor Plan (Lobby &amp; 2nd Floors)</td>
<td>48</td>
</tr>
<tr>
<td>Westin Gaslamp Quarter Floor Plans (4th Floor)</td>
<td>50</td>
</tr>
</tbody>
</table>

**WI-FI**

Wi-Fi is available throughout the conference venue. To connect, find the below-listed network name and then enter the password.

Network Name: IEMDC2019 | Password: IEMDC2019
Welcome to San Diego and to the 11th edition of the IEEE International Electric Machines and Drives Conference (IEMDC). IEMDC is a biennial conference that is cosponsored by four IEEE societies, Industry Applications Society (IAS) Industrial Electronics Society (IES), Power Electronics Society (PELS), and Power and Energy Society (PES).

The IEMDC Program Committee has put a lot of time and effort into creating a vibrant technical program including one full-day of tutorials covering a broad range of topics, four plenary sessions presented by renowned experts, three days of technical sessions inclusive of 54 oral sessions, several special sessions, and three poster sessions, two industry RAP sessions, and the IEMDC exposition featuring the latest industry innovations from 15 exhibitors.

In addition to the technical program, the conference will also feature a memorable conference banquet held in the famous USS Midway aircraft carrier in downtown San Diego. The conference venue/hotel, the Westin San Diego Gaslamp Quarter is located in the heart of downtown San Diego, so be sure to take advantage of any downtime to explore and experience the beautiful city of San Diego.

We are grateful to you – our partners and attendees – for all your technical contributions which have already helped make IEMDC 2019 a great success. I am personally very grateful to the IEMDC Organizing Committee made up of individuals who serve as volunteers and reviewers. It is mainly due to their tireless efforts that IEMDC 2019 continues to take place with this strong of a technical program and highly-anticipated social events.

On behalf of both the IEMDC 2019 Organizing Committee and Steering Committee, I would like to thank you for your interest and support of our conference. I look forward to spending these next few days learning alongside you.

Sincerely,

Ayman EL-Refaie
IEMDC 2019 General Chair
GENERAL INFORMATION

**Registration** *(California Foyer)*

- **Sunday, May 12**: 7:00 am–5:00 pm
- **Monday, May 13**: 7:30 am–7:00 pm
- **Tuesday, May 14**: 7:30 am–6:00 pm
- **Wednesday, May 15**: 7:30 am–3:00 pm

**Exhibition** *(California Ballroom)*

- **Monday, May 13**: 12:00 pm–5:00 pm
- **Tuesday, May 14**: 9:00 am–5:00 pm
- **Wednesday, May 15**: 9:00 am–3:00 pm

**Materials Purchase**

Additional copies of the Conference Proceedings/USB will be available for purchase at the registration desk for a fee of $100.

**Event Conduct and Safety Statement**

IEEE believes that science, technology, and engineering are fundamental human activities, for which openness, international collaboration, and the free flow of talent and ideas are essential. Its meetings, conferences, and other events seek to enable engaging, thought-provoking conversations that support IEEE’s core mission of advancing technology for humanity. Accordingly, IEEE is committed to providing a safe, productive, and welcoming environment to all participants, including staff and vendors, at IEEE-related events. IEEE has no tolerance for discrimination, harassment, or bullying in any form at IEEE-related events. All participants have the right to pursue shared interests without harassment or discrimination in an environment that supports diversity and inclusion. Participants are expected to adhere to these principles and respect the rights of others. IEEE seeks to provide a secure environment at its events. Participants should report any behavior inconsistent with the principles outlined here, to on site staff, security or venue personnel, or to eventconduct@ieee.org.
IEMDC 2019 Organizing Committee

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Publicity Chairs
Jiangbiao He (USA); Alireza Fatemi (USA)

Exhibition Chairs
Alireza Fatemi (USA); Philippe Wendling (USA)

Local Chair
Tan Pham (USA)
<table>
<thead>
<tr>
<th>Topic Area</th>
<th>Chairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotating Electrical Machines</td>
<td>Andrea Cavagnino (Italy)</td>
</tr>
<tr>
<td></td>
<td>Stjepan Stipetić (Croatia)</td>
</tr>
<tr>
<td></td>
<td>Pinjia Zhang (China)</td>
</tr>
<tr>
<td></td>
<td>Ali Bazzi (USA)</td>
</tr>
<tr>
<td></td>
<td>Mahesh Krishnamurthy (USA)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Drives</td>
<td>Giulio De Donato (Italy)</td>
</tr>
<tr>
<td></td>
<td>Shafiq Ahmed Odhano (UK)</td>
</tr>
<tr>
<td></td>
<td>Jiangbiao He (USA)</td>
</tr>
<tr>
<td></td>
<td>Arijit Banerjee (USA)</td>
</tr>
<tr>
<td></td>
<td>David Díaz Reigosa (Spain)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Machines, Electromagnetic Actuators</td>
<td>Francisco J. Márquez-Fernández (Sweden)</td>
</tr>
<tr>
<td>and Sensors</td>
<td>Gaizka Almandoz Larralde (Spain)</td>
</tr>
<tr>
<td></td>
<td>Nick Baker (UK)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal, Materials and Efficiency Issues</td>
<td>Shafigh Nategh (Sweden)</td>
</tr>
<tr>
<td></td>
<td>Michael Galea (UK)</td>
</tr>
<tr>
<td></td>
<td>Antonio Griffo (UK)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition Monitoring, Fault Diagnosis and</td>
<td>Sang Bin Lee (Korea)</td>
</tr>
<tr>
<td>Prognosis</td>
<td>Antonio Cardoso (Portugal)</td>
</tr>
<tr>
<td></td>
<td>Thomas Wolbank (Austria)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation</td>
<td>Rakib Islam (USA)</td>
</tr>
<tr>
<td></td>
<td>Rajib Mikail (USA)</td>
</tr>
<tr>
<td></td>
<td>Erkan Mese (Turkey)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy and Grid-Connected Applications</td>
<td>Marko Hinkkanen (Finland)</td>
</tr>
<tr>
<td></td>
<td>Juan Manuel Guerrero (Spain)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>High-Speed Motors, Bearingless Motors and</td>
<td>Eric Severson (USA)</td>
</tr>
<tr>
<td>Magnetic Bearings</td>
<td>Akira Chiba (Japan)</td>
</tr>
<tr>
<td></td>
<td>Wolfgang Gruber (Austria)</td>
</tr>
<tr>
<td></td>
<td>Junichi Asama (Japan)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>High-Performance Linear Machines and Drives</td>
<td>Wei Xu (China)</td>
</tr>
<tr>
<td></td>
<td>Rabiul Islam (Australia)</td>
</tr>
<tr>
<td></td>
<td>Ion Boldea (Romania)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiphase Machines and Drives</td>
<td>Jorge Rodas (Paraguay)</td>
</tr>
<tr>
<td></td>
<td>Obrad Dordevic (UK)</td>
</tr>
<tr>
<td></td>
<td>Mario Duran (Spain)</td>
</tr>
</tbody>
</table>
SCHEDULE-AT-A-GLANCE

SUNDAY, MAY 12
7:00 am–5:00 pm  
Registration Open  
California Foyer

8:00 am–12:00 pm  
Morning Tutorials  
Santa Fe

1:00 pm–5:00 pm  
Afternoon Tutorials  
Santa Fe

MONDAY, MAY 13
7:30 am–7:00 pm  
Registration Open  
California Foyer

8:00 am–8:40 am  
Opening Session  
San Diego Ballroom

8:40 am–9:20 am  
Plenary Session #1: Medium Voltage Megawatt Drive Systems – Challenges and Opportunities  
San Diego Ballroom

9:20 am–10:00 am  
Plenary Session #2: Simulation Driven Innovation – Changing the Role of Simulation in the Design of Electrical Devices  
San Diego Ballroom

10:30 am–12:10 pm  
Special Sessions and Regular Oral Sessions  
Multiple Locations

12:00 pm–5:00 pm  
Exposition Open  
California Ballroom

12:10 pm–1:00 pm  
Lunch  
California Ballroom

1:00 pm–2:40 pm  
Special Sessions and Regular Oral Sessions  
Multiple Locations

2:40 pm–3:10 pm  
PM Coffee Break  
California Ballroom

3:10 pm–4:50 pm  
Special Sessions and Regular Oral Sessions  
Multiple Locations

4:50 pm–6:20 pm  
Industry RAP Session  
San Diego Ballroom
TUESDAY, MAY 14

7:30 am–6:00 pm
Registration Open
California Foyer

8:00 am–8:40 am
Plenary Session #3: Integrated Motor Compressor: A System Approach
San Diego Ballroom

8:40 am–9:55 am
Special Sessions and Regular Oral Sessions
Multiple Locations

9:00 am–5:00 pm
Exposition Open
California Ballroom

9:55 am–10:30 am
AM Coffee Break
California Ballroom

10:30 am–12:00 pm
Poster Session
California Ballroom

12:00 pm–1:00 pm
Lunch
California Ballroom

1:00 pm–2:40 pm
Regular Oral Sessions
Multiple Locations

2:40 pm–3:10 pm
PM Coffee Break
California Ballroom

3:10 pm–4:50 pm
Regular Oral Sessions
Multiple Locations

4:50 pm–6:20 pm
Industry RAP Session
San Diego Ballroom

WEDNESDAY, MAY 15

7:30 am–3:00 pm
Registration Open
California Foyer

8:00 am–8:40 am
Plenary Session #4: Advanced Mechatronics and Control for Precision Motion Control
San Diego Ballroom

8:40 am–9:55 am
Regular Oral Sessions
Multiple Locations

9:55 am–10:30 am
AM Coffee Break
California Ballroom

10:30 am–12:00 pm
Poster Session
California Ballroom

12:00 pm–1:00 pm
Lunch
California Ballroom

1:00 pm–2:30 pm
Poster Session
California Ballroom

2:30 pm–3:00 pm
PM Coffee Break
Multiple Locations

3:00 pm–4:40 pm
Regular Oral Sessions
Multiple Locations

7:00 pm
Conference Dinner aboard the USS Midway
910 N Harbor Drive, San Diego, CA 92101
*Transportation to the USS Midway is not provided.*
SUNDAY: TUTORIALS

Morning Tutorials

8:00 am–12:00 pm
Santa Fe

S1: Control of AC eDrives: From Theory to Implementation
Gianmario Pellegrino, Radu Bojoi, Paolo Pescetto, Sandro Rubino

The demand for premium energy efficiency and the challenges of transportation electrification have drawn the attention on advanced, variable speed electric drives (eDrives). Today, there are many custom eDrives solutions, employing different control algorithms. Implementation-wise, engineers within the industry are facing many challenges to put in production eDrives. In addition, the eDrives must be properly tested to validate their performance towards the application requirements, since the nameplate data and the rated parameters declared by the suppliers are very often insufficient to this purpose. The tutorial is addressed to engineers involved in industrial R&D and within academia. The tutorial provides an overview of AC drives control techniques, including vector control and direct flux and torque control. Different AC machine types will be covered, including Induction Motors (IM), Surface Mount- and Internal- Permanent Magnet (SPE and IPM) machines, and Synchronous Reluctance (SyR) machines. The electrical motor (eMotor) parameters and power converter current and voltage limits will be translated into optimal control trajectories such as the Maximum Torque Per Ampere (MTPA) and Maximum Torque Per Volt (MTPV) regions. The tutorial will present results from experimental cases and provide simulation models and exercises.

This course is a recommended refresher tutorial for the afternoon tutorial titled S1: Simulating Advanced Motor Control Systems.

Plaza A/B

S2: Electrical Vehicles: Power Traction Motors Design Aspects
Mircea Popescu, Giuseppe Volpe, Jonathan Godbehere

There is currently significant activity in the mass manufacturing and development of electric machines for automotive applications where a wide variety of possible solutions can be seen. This tutorial aims to evaluate a range of the most common design options in terms of performance, cost and manufacturability. Development of an EV powertrain is a complex systems problem and achieving an optimal system design requires an evaluation of many different concepts and topologies as well as a detailed understanding of the system interactions. These interactions are typically cross-specialism or discipline, involve different teams and often require multi-physics analysis. Design and simulation tools are crucial to evaluating different design topologies as well as identifying and understanding important system interactions. The tutorial will be focused upon a set of typical electric machine specifications through which the following design variations will be explored for traction motors in EVs and proposes simple modifications that can improve the motor performance.

La Jolla

S3: Health Monitoring and Fault-Tolerant Operation of Variable Frequency Drives in On-the-Move Industry Applications
Jiangbiao He, Behroz Mirafzal

On-the-move industry comprises a variety of technologies including industrial, service and medical robotics, aircraft, electric and hybrid vehicles, trains, and drones, etc. Despite their differences, they have common specific characteristics and requirements. Development of an EV powertrain is a complex systems problem and achieving an optimal system design requires an evaluation of many different concepts and topologies as well as a detailed understanding of the system interactions. These interactions are typically cross-specialism or discipline, involve different teams and often require multi-physics analysis. Design and simulation tools are crucial to evaluating different design topologies as well as identifying and understanding important system interactions. The tutorial will be focused upon a set of typical electric machine specifications through which the following design variations will be explored for traction motors in EVs and proposes simple modifications that can improve the motor performance.

This course is a recommended refresher tutorial for the afternoon tutorial titled S1: Simulating Advanced Motor Control Systems.
S4: Design Considerations for Compact Motor Drives Using Silicon and Wide Bandgap (WBG) Power Electronics Switching Devices
Krishna Shenai, PhD

Wide Bandgap (WBG) power electronics switching devices made on SiC and GaN promise significantly increased energy efficiency compared to silicon power devices in a wide range of power electronics circuits including the motor drives. However, their market penetration is slow largely due to design complexity, high cost and unknown application-level reliability. This half-day short course will provide an overview of commercial state-of-the-art WBG power devices and important design criteria that must be considered when developing compact WBG-based compact motor drives in key applications including HEV/EV traction controllers and battery chargers. Outline: The proposed outline for this half-day short course is as follows:

• Base power electronics circuits – DC/DC converter – Inverter
• Overview of state-of-the-art commercial semiconductor power devices – Silicon devices – GaN transistors – SiC diodes and MOSFETs
• Advanced power switch modules
• Gate drive and control considerations
• Converter design approach for performance
• Thermal and reliability considerations – Application-level – Switch-level
• Cost vs. Performance vs. Reliability trade-offs
• Recommendations for compact power converter design

Afternoon Tutorials
1:00 pm–5:00 pm
Santa Fe

S1: Simulating Advanced Motor Control Systems
David Wilson, Keshav Sundaresh

This session focuses on advanced motor control systems and the proper techniques required to simulate their performance. Field-Oriented control topologies will be presented due to the popularity and universal applicability of the FOC algorithm. By using the “4-step FOC design process”, Field-Oriented control is correlated to the four steps used for torque control of a brush DC motor, which is far easier to comprehend. Popular techniques used for motor current sampling and reconstruction will be presented, as well as stationary to synchronous frame transformations, cascaded speed and torque regulators, and Space Vector Modulation to drive the motor windings from the torque regulator outputs. To save cost, many manufacturers are moving away from systems that require a shaft sensor to determine the flux linkage angle. This session discusses several popular “sensorless” FOC techniques, including direct EMF reconstruction, PI-based observers, and Sliding-Mode observers.

In most cases, a simulation is created to test the assumptions and interaction of each of the FOC components. Since FOC is almost exclusively implemented as an Interrupt Service Routine on a processor, it is very important to design the simulation to exactly mimic the implementation of the ISR, including signal delays, interrupt triggering time, and order of execution. It is not adequate to allow the simulator to treat the sampling process as a mathematical impulse function, where the simulator is allowed to determine the order of execution of each block. Techniques are shown for how to trigger each step of the FOC process to force the order of execution to be exactly how it would occur in the processor ISR.

Several lab examples are provided using Altair’s Embed Basic to provide instruction on the proper techniques for simulating an FOC-based motor control system. This includes how to set up the simulation, how to create different motor models, implementing the FOC process, encoder modeling, sensorless modeling, designing the PWM and SVM blocks, ADC simulation, PI regulator simulation, motor load simulation, and designing the DC bus circuit. Parametric analysis of a linear system is assumed, but techniques are also presented to show how to deal with non-linear systems. All simulation labs are provided to the attendee free of charge. A final lab example will contain all the component blocks of a disassembled FOC simulation, and each block must be properly connected to the other blocks to achieve the correct FOC outputs. A separate simulation showing the correct connections is also provided for reference.

This courses is a recommended follow-up tutorial for the morning tutorial titled S1: Control of AC eDrives: From Theory to Implementation.

Plaza A/B

S2: Lose Your Bearings: A Deep Dive into Magnetically Suspended Motors
Eric Severson, Akira Chiba, Wolfgang Gruber, Christof Zwyssig, Rafał Jastrzębski

The goal of this tutorial is to train participants on how and when to use magnetic suspension in their motor systems in place of conventional bearings. In the first part of the tutorial,
participants will analyze the shortcomings of conventional bearings, investigate applications where magnetic suspension systems are most advantageous, and explore the basic operation of magnetic bearings and bearingless motors. In the second part of the tutorial, participants will apply these concepts to develop advanced and high-performance magnetic suspension systems. This will include new design and control concepts of this technology to reach high power density, ultra-high rotational speeds, and overcome manufacturability and sensor challenges. Ultimately, participants will evaluate the potential for magnetic suspension technology to disrupt their product development or research field. For magnetic bearings, the tutorial material will include the classical heteropolar radial magnetic bearing as well as hybrid and homopolar magnetic bearings. Bearingless motors, where the magnetic field of a motor is modified to function as a magnetic bearing, are an up and coming technology that offers highly integrated designs with advantageous rotor dynamics and fewer components but has seen little commercial deployment to date. The instructors will present recent research that enables bearingless motors to reach industrial power levels and/or ultra-high rotational speeds through new combined winding technology, optimal machine design, and bearingless slice motor topologies. In today’s motor systems, bearings are typically the first components to fail and can be a significant source of losses—especially at high rotational speeds. Furthermore, oil lubrication and hydrodynamic bearings require periodic maintenance, require bulky external pumping infrastructure, and oil seepage can contaminate and interfere with broader processes. Examples of critical problems caused by conventional bearings can be found in nearly every type of rotor system: from MW-scale HVAC chillers (where refrigerant contaminated by bearing lubricant reduces system efficiency by over 10%) to ≤1 kW optical beam applications (where high-speeds, vacuum environments, and low vibration requirements require expensive bearings with short lifetimes). Recent developments in power electronic devices, embedded control systems, and magnetic materials are creating new and low-cost opportunities for magnetic suspension systems. This is driving renewed industrial interest in magnetic bearings and bearingless motor technology.

Part 1: An introduction to partial discharge (PD), including the physics behind PD and how it manifests itself within rotating machine stator insulation. A summary of the history of the development of the PD detection and sensor technology is provided including a review of the latest PD sensor and monitoring technologies.

- What is a partial discharge?
- Why/where can PD be generated? Physics behind the phenomena.
- Which HV assets can be affected?
- Machines faults statistics.
- Winding constructions overview.
- Types of PD affecting rotating machine stator insulation.
- Consequence of the PD degenerative phenomena
- Visual examples of PD types, pictures and videos.
- Motivations for PD detection.
- PD detection methods and sensors. General overview.
- Online versus offline PD testing
- Online PD detection methods and sensors. Focus on rotating machines.
  - Sensors for PD detection in rotating machines.
  - PD detection at machine
  - PD detection from remote switchgear.
  - Overview of PD detection for VSD-driven rotating machines.

Part 2: Case studies from past OLPD test projects from 10 years of industrial applications are presented, covering all the main types of HV rotating machines in operation within industrial facilities. The case studies include: HV generators, direct on-line HV motors, and ASD/VSD operated HV motors, an additional case study will cover the other critical HV assets in the network including transformers, cables and switchgear. In this part case studies are utilized to show in practice how PD (theoretically presented in part 1) can affect the specific assets with an emphasis on rotating machines and briefly on power cables, transformers and switchgear. Here the idea is to start from the acquired monitoring data then:

- Show challenges and solution to perform data de-noising.
- Infer the asset condition assessment (based on testing data).
- To then show and compare the findings from visual inspections and maintenance interventions
- To conclude part 2, the development, implementation, and validation of an OLPD condition monitoring system for VSD driven motor is presented.

La Jolla

S3: Partial Discharge (PD) Monitoring of High Voltage Rotating Machines: Introduction, Theory, Best Practice and Case Studies from 10 years of Industrial Applications
Lewis Dodd, Riccardo Giussani

This tutorial introduces the technique of on-line partial discharge (OLPD) monitoring of in-service, high voltage (HV ≥ 3 kV) rotating machine. The tutorial is in three parts:
Part 3: In the last part of the tutorial, sets of OLPD continuous monitoring data from rotating machines will be presented and their interpretation explained. This part is kept open and it will be tailored on the day. The theory is presented in part 2, and part 3 can be used to clarify any doubt of the audiences through the analysis of real OLPD data from selected on the day case studies.

**Del Mar**

**S4: High-Performance Linear Induction Machines for Industrial Applications**  
*Wei Xu, Marcello Pucci, Ion Boldea*

The tutorial aims to share the advancements in the new linear machine topologies, integrated modeling, multi-objective optimization techniques, and high-performance control strategies and its emerging applications in transportation and energy conversion systems. Researchers & engineers from electrical, mechanical and information fields may find it useful when dealing with transportation motor and drive related design, optimization and control development, mechanical design and analysis, and so on. The main subject of the tutorial is linear induction motors (LIMs). Starting from a brief structural description of such motors, their main applications will be exposed in the tutorial with specific reference to MAGLEV (Magnetically Levitation) vehicles, urban people movers (such as linear metro, light railway, etc.), X-Y planar motion industrial platforms, launchers, and actuators for industrial and automotive.

As a first step, the main differences between rotating and linear induction motors will be highlighted, focusing on the aspects of static and dynamic end effects as well as transversal edge effects. The typical structure of LIMs will be treated, with specific reference to the secondary sheet and primary winding configurations. Single-sided LIMs (S-LIMs) and Double-sided ones (D-LIMs) will be described in detail, focusing on normal force effects. Design criteria of LIMs will be specifically exposed, emphasizing the main differences with the classic rotating induction motor design, caused by the presence of large air-gaps, high leakage inductances as well as the end effects.

Both static and dynamic models of LIMs will be introduced, including the so-called end-effects, magnetic saturation, non-linear traits influenced by PWM modulation, and so on. Suitable parameter estimation methods will be then described. Afterward, control techniques specifically devised for LIMs, like field oriented control, input-output feedback linearization control, active disturbance rejection control, model predictive control, efficiency optimization control, etc., will be introduced in detail. Finally, sensorless techniques with strong robustness capability specifically developed for LIMs will be shown.
MONDAY: SESSIONS

PLENARY SESSIONS

8:40 am–9:20 am
San Diego Ballroom

Medium Voltage Megawatt Drive Systems – Challenges and Opportunities
Venkateshwaran Krishnan, Director of Business Development and Special Programs

The last decade has seen the advent of several new technologies available to the high-speed electrical drive industry: high energy permanent magnet machine technology, wide Band Gap switching device technology, and advanced bearings and Tribology, including maturity of magnetic bearings. Calnetix has been at the front and center of all advances in the high-speed machine and drive technology solutions development, and recently achieved several milestones in the development and validation MV MW high-speed drive solution using the latest technologies for the US Department of Energy. The experience gained from the development highlights the significant benefits of maturing the technology. At the same time, there are several technology gap areas that were revealed in the development process that provide an opportunity for further work. In addition, some of the other challenges of manufacturing and cost- economics of this technology also came to the fore, which present opportunities for large scale additive manufacturing and further improvements in material science and manufacturing. This keynote address will take the aspects of the development process and lessons learned to highlight the technology gaps and areas of opportunity for future work and the potential for the electric drive industry with these technologies.

9:20 am–10:00 am
San Diego Ballroom

Plenary Session #2: Simulation Driven Innovation - Changing the Role of Simulation in the Design of Electrical Devices
Uwe Schramm, PhD, Chief Technical Officer, Structural and Electromagnetic Solutions, Altair

The ability of a company to thrive in today’s economy depends on new and innovative products. Profitable enterprises require a constant stream of creative ideas moved into products to win new customers and satisfy existing customers' needs. In the ideation phase, when the freedom to create and modify a design is at its peak and risk is low, creative use of computer-aided engineering can enable quantification of design performance based on the concept. This supplants subjective decision making and may lead to better product outcomes. Computational techniques become tools for requirements-based design creation rather than merely tools for performance assessment. Eventually, this will lead to a more efficient design process which will produce more innovative products. In the age of electric vehicles and autonomous driving with sensors embedded in every product, multi-physics simulations, and optimization that include electric devices, like motors and sensors is increasingly becoming a necessity. Computational electromagnetics has matured over the past three decades to become industry standard and hence reducing extensive testing. Simulations are also leading to significantly faster design iterations and therefore reducing development cost and improving design performance. In this talk, Dr. Schramm will provide the current state of the art multi-physics simulations that span over a wide range of products. And will address simulation technologies that are helping improve the measurement process in multiple disciplines.

ORAL SESSIONS

10:30 am–12:10 pm
ROOM: PLAZA A

Design of High-Speed Machines
Sessions Chairs: Eric Severson; Akira Chiba

10:30 am–10:55 am
Topological Bearingless and Design of Slotted Bearingless High-Speed Motor
Bianca Klammer1, Hubert Mitterhofer1, Andreas Zöchbauer2, Wolfgang Gruber3
1Linz Center of Mechatronics GmbH, Austria; 2Johannes Kepler University Linz, Austria

10:55 am–11:20 am
Comparison of Bearingless Slice Motor Topologies for Pump Applications
P. Puentener1, M. Schuck1, D. Steinert1, J.W. Kolar1
1ETH Zurich, Switzerland; 2Levitronix GmbH, Switzerland

11:20 am–11:45 am
Combined Winding Structure of Consequent-Pole Bearingless Motors with Parallel Motor Winding Topology
Takahiro Noguchi, Hiroya Sugimoto, Akira Chiba
Tokyo Institute of Technology, Japan
11:45 am–12:10 pm | SD-009709
Practical Considerations in the Design and Manufacture of Ultrahigh-Speed Switched Reluctance Machine over 1 Million RPM
Cheng Gong, Sufei Li, Thomas Habetler
Georgia Institute of Technology, USA

10:30 am–12:10 pm
ROOM: PLAZA C
Linear Machines
Sessions Chairs: Nick Baker; Thomas Lipo

10:30 am–10:55 am
Simulation and Experimental Validation of Equivalent Circuit Parameters and Core Loss in a Tubular Permanent Magnet Linear Generator for Free Piston Engine Applications
Jayaram Subramanian, Fereshteh Mahmudzadeh, Mehar Bade, Parviz Famouri
West Virginia University, USA

10:55 am–11:20 am
Multi-Segment Sliding Mode Control of the Planar Switched Reluctance Motor for Precision Positioning
Xiao-Sheng Yang, Su-Dan Huang, Guang-Zhong Cao, Chao Wu, Hong-Jin Hu, Xing-Dong Fu
Shenzhen University, China

11:20 am–11:45 am
Analysis of A New Partitioned-primary Flux-reversal Hybrid-excited Linear Motor
Zhiqiang Zeng, Qinfen Lu, Xiaoyan Huang
Zhejiang University, China

10:30 am–12:10 pm
ROOM: PLAZA B
Bearing Fault Diagnosis
Sessions Chairs: A. J. Marques Cardoso; Thomas Wolbank

10:30 am–10:55 am
Detection of Single-Axis Pitch Bearing Defect in a Wind Turbine Using Electrical Signature Analysis
Lijun He¹, Liwei Hao¹, Di Pan², Wei Qiao²
¹GE Global Research Center, USA; ²University of Nebraska-Lincoln, USA

10:55 am–11:20 am
In-situ Thermal and Mechanical Fibre Optic Sensing for In-service Electric Machinery Bearing Condition Monitoring
Anees Mohammed, Siniša Djurović
The University of Manchester, UK

11:20 am–11:45 am
Quantification of Rolling-Element Bearing Fault Severity of Induction Machines
Shen Zhang¹ ² ³, Bingnan Wang¹, Makoto Kanemaru², Chungwei Lin¹, Dehong Liu¹, Koon Hoo Teo¹, Thomas G. Habetler⁴
¹Mitsubishi Electric Research Laboratories, USA; ²Mitsubishi Electric Corp., Japan; ³Georgia Institute of Technology, USA

11:45 am–12:10 pm
Enhanced Wind Turbine Main Drivetrain Gearbox and Bearing Monitoring and Diagnostics via Information Fusion of Acoustic, Electrical, and Vibration Signatures
Lijun He¹, Jay Unnikrishnan², Liwei Hao¹, Brett Matthews¹, Wei Qiao³
¹GE Global Research Center, USA; ²Qualcomm Research, USA; ³University of Nebraska-Lincoln, USA
MONDAY: SESSIONS

10:55 am–11:20 am
**Synchronized Six-Step Voltage Generation in High-Speed PMSM Drive**
Leszek Jarzebowicz, Maciej Cisek
Gdansk University of Technology, Poland

11:20 am–11:45 am
**Speed Range Extension of a Dual-Stator PM Machine Using Winding Switching Strategy**
Shukang Lyu, Hui Yang, Heyun Lin, Ya Li, Hao Zheng
Southeast University, China

11:45 am–12:10 pm
**Extended Operating Range of Induction Machines Using Switched Stator Windings**
Daniel Scharfenstein, Rik W. De Doncker
RWTH Aachen University, Germany

10:30 am–12:10 pm
ROOM: SIERRA B

**Permanent Magnet Machines-1**
Sessions Chairs: Babk Fahimi; Mahesh Krishnamurthy

10:30 am–10:55 am
**Comparative Studies of Fractional/Integer-Slot Consequent Pole Permanent Magnet Machines**
R. Zhou, G.J. Li, Z.Q. Zhu, Y.X. Li, M.P. Foster, D.A. Stone
The University of Sheffield, UK

10:55 am–11:20 am
**Modeling the Flux-Linkage in Permanent Magnet Synchronous Machines**
Luis Ayala¹, Albert Schwinn¹, David Moule², Ralph Kenne³
¹ZF Group, Germany; ²ZF Group, UK; ³Technische Universität München, Germany

11:20 am–11:45 am
**Investigation of Integer/Fractional Slot Consequent Pole PM Machines with Different Rotor Structures**
R. Zhou, G.J. Li, Z.Q. Zhu, Y.X. Li, M.P. Foster, D.A. Stone
The University of Sheffield, UK

11:45 am–12:10 pm
**Quantitative Comparison among Outer Rotor PM Machine with Different Rotor Topologies**
F. Li, K. Wang, H. Y. Sun, H. Zhang, L. Zhang
Nanjing University of Aeronautics and Astronautics, China

10:30 am–12:10 pm
ROOM: SANTA FE

**Induction Machines-1**
Sessions Chairs: Andrea Cavagnino; Silvio Vaschetto

10:30 am–10:55 am
**A Form Based Induction Machine Efficiency Estimation Tool**
Maher Al-Badri¹, Pragasen Pillay², Pierre Angers³
¹University of Alaska Fairbanks, USA; ²Concordia University, Canada; ³Laboratoire des Technologies de l’Énergie Institut de Recherche (LTE), Hydro-Québec, Canada

10:55 am–11:20 am
**Torque Ripple Investigation in Squirrel Cage Induction Machines**
Alessandro Marfoti, Giacomo Sala, Luca Papini, Paolo Bolaganesi, Chris Gerada
University of Nottingham, UK

11:20 am–11:45 am
**Induction Motor Analysis using Magnetostatic Finite Element Simulations Considering Skewing**
Matteo Carbonieri, Nicola Bianchi, Luigi Alberti
University of Padova, Italy

11:45 am–12:10 pm
**The Role of End-Winding in Building Up Parasitic Capacitances in Induction Motors**
Konstantin Vostrov, Juha Pyrhönen, Jero Ahola
Lappeenranta-Lahti University of Technology, Finland

1:00 pm–2:40 pm
ROOM: PLAZA A

**High Speed Machines Applications**
Sessions Chairs: Wolfgang Gruber; Giuseppe Fabri

1:00 pm–1:25 pm
**An Integrated Electric Motor Driven Compressor Supported by Magnetic Bearings**
Lei Zhu, Wolfgang Faller
Solar Turbines Inc., USA

1:25 pm–1:50 pm
**High Speed Synchronous Reluctance Motors for Electric Vehicles: A Focus on Rotor Mechanical Design**
Andrea Credo¹, Giuseppe Fabri², Marco Villani², Mircea Popescu³
¹University of L’Aquila, Italy; ²Motor Design Ltd., UK
1:50 pm–2:15 pm
Active Radial Electromagnetic Damper
Alexei Filatov, Larry Hawkins
Calnetix Technologies, LLC, USA

2:15 pm–2:40 pm
Implementation of a Bearingless Axial-Force/Torque Motor Fan with Flex-PCB Windings
Wolfgang Gruber¹, Walter Bauer¹, Daniel Wetsch¹, Bianca Klanner², Nobuyuki Kurita³
¹Johannes Kepler University Linz, Austria; ²Linz Center of Mechatronics GmbH, Austria; ³Gunma University, Japan

1:00 pm–2:40 pm
ROOM: PLAZA B

Stator Winding Insulation Faults
Sessions Chairs: A. J. Marques Cardoso; Jiangbiao He

1:00 pm–1:25 pm
Analytical Model of a Six-Phase PMSM for the Simulation of Stator Winding Faults on Turn Level
Simon Foitzik, Martin Doppelbauer
Karlsruhe Institute of Technology, Germany

1:25 pm–1:50 pm
Investigation on Parameters Influencing Turn-to-Turn Insulation Stress of Form-Wound Medium-Voltage Induction Machines
A. Qerkini¹, M.A. Vogelsberger², C. Zoeller¹, M. Joerg³, T. Wolbank⁴
¹Technische Universität Wien, Austria; ²Bombardier Transportation Austria GmbH, Austria; ³Bombardier Transportation, Switzerland

1:50 pm–2:15 pm
On-Line Inter-Turn Short-Circuit Fault Diagnosis in Switched Reluctance Motors
D.S.B. Fonseca, Antonio J. Marques Cardoso
CISE, Universidade da Beira Interior, Portugal

2:15 pm–2:40 pm
A More Robust Stator Insulation Failure Prognosis for Inverter-Driven Machines
William R. Jensen, Elias G. Strangas, Shanelle N. Foster
Michigan State University, USA

1:00 pm–2:40 pm
ROOM: PLAZA C

Magnetic Gears
Sessions Chairs: Chris Gerada; Mark Thiele

1:00 pm–1:25 pm
Nonlinear Analysis of Magnetic Gear Dynamics Using Superposition and Conservation of Energy
Matthew C. Gardner, Hamid A. Toliyat
Texas A&M University, USA

1:25 pm–1:50 pm
Proposal of Magnetic Geared Screw Motor
Kazuaki Takahara, Katsuhiro Hirata, Noboru Niguchi
Osaka University, Japan

1:50 pm–2:15 pm
High-Torque-Density Low-Cost Magnetic Gear Utilizing Hybrid Magnets and Advanced Materials
Ali Al-Qarni, Fan Wu, Ayman EL-Refaie
Marquette University, USA

2:15 pm–2:40 pm
A High Torque Density Halbach Rotor Magnetic Gear
Ho Yin (David) Wong¹, Jonathan Z. Bird³, David Barnett², Wesley Williams²
¹Portland State University, USA; ²University of North Carolina at Charlotte, USA

1:00 pm–2:40 pm
ROOM: SIERRA A

Control of electrical drives (I)
Sessions Chairs: Lijun He; Yves Perriard

1:00 pm–1:25 pm
Torque Ripple Mitigation via Optimized Current Profiling in Interior Permanent Magnet Synchronous
Pengyuan Chen¹, Taowen Chen¹, Jingchen Liang¹, Babak Fahimi², Mehdi Moallem²
¹The University of Texas at Dallas, USA; ²Isfahan University of Technology, Iran

1:25 pm–1:50 pm
Permanent Magnet Synchronous Machine Emulation Based on Power Hardware-in-the-Loop Simulation
Xiaomin Zou¹, Xi Xiao¹, Peng He², Yuyang Song¹
¹Tsinghua University, China; ²Shaanxi Aero Electric Co., Ltd., China
MONDAY: SESSIONS

1:50 pm–2:15 pm
Sensorless Control Method for Doubly Salient StarterGenerator with Two-section Interlaced-rotor Structure
Chuanzhou Shi, Huizhen Wang, Weifeng Liu
Nanjing University of Aeronautics and Astronautics, China

2:15 pm–2:40 pm
Simultaneous Torque and Radial Force Ripple Mitigation in DQ Controlled Switched Reluctance Machines
Omer Gundogmus1, Lavanya Vadamodala1, Yilmaz Sozer1, John Kutz2, Joshua Tylenda3, Ronnie L. Wright4
1University of Akron, USA; 2DCS Corp., USA; 3United States Army CCDC Ground Vehicle Systems Center, USA

1:00 pm–2:40 pm
ROOM: SIERRA B

Interior Permanent Magnet Machines-2
Sessions Chairs: Mahesh Krishnamurthy; Claudio Bianchini

1:00 pm–1:25 pm
Comparative Study of Advanced Stator Interior Permanent Magnet Machines
Ya Li, Hui Yang, Heyun Lin, Hao Zheng
Southeast University, China

1:25 pm–1:50 pm
A Novel Hybrid-Pole Interior PM Machine with Magnet-Axis-Shifting Effect
Hui Yang1, Weijia Wang1, Heyun Lin1, Z.Q. Zhu1, Shukang Lyu1, Shuangxia Niu2
1Southeast University, China; 2The University of Sheffield, UK; 3The Hong Kong Polytechnic University, China

1:50 pm–2:15 pm
Combined Analytic – Linear-FE Approach for Fast Stress Analysis of High-Speed Interior PM Rotors
Matteo F. Iacchetti1, Mircea Popescu2, James Goss2
1The University of Manchester, UK; 2Motor Design Ltd., UK

2:15 pm–2:40 pm
Interactive Ripple Harmonics Minimization of Fractional Slot Permanent Magnet Machines using Space-shifted Wye-Delta Winding
Md Sariful Islam1, Md Ashfanoor Kabir2, Rajib Mikaii3, Iqbal Husain1
1North Carolina State University, USA; 2ABB Inc., USA

1:00 pm–2:40 pm
ROOM: SANTA FE

Induction Machines-2
Sessions Chairs: Andrea Cavagnino; Silvio Vascchetto

1:00 pm–1:25 pm
A Brushless Doubly Fed Machine With Separated Field and Armature Windings in Dual Stators
Zhiwei Zhang
The Ohio State University, USA

1:25 pm–1:50 pm
Induction Machine Efficiency Evaluation Using the Finite Element Analysis Software and a New Mechanical Loss Formula
Mahmud Ghasemi Bijan, Pragasen Pillay
Concordia University, Canada

1:50 pm–2:15 pm
Computation of Initial Conditions for Dynamic Analysis of a Doubly Fed Induction Machine Based on Accurate Equivalent Circuit
V. Seshadri Srvana Kumar
Indian Institute of Technology Hyderabad, India

2:15 pm–2:40 pm
Torque-Density Improvement in Brushless Doubly-Fed Reluctance Machines using Additional Stator Winding
Shivang Agrawal, Arijit Banerjee
University of Illinois Urbana-Champaign, USA

3:10 pm–4:50 pm
ROOM: PLAZA A

SSHS3: Bearingless Machine Modeling
Sessions Chairs: Wolfgang Gruber; Emil Kurvinen

3:10 pm–3:35 pm
Thermo-Mechanical Modelling of Bearing Chambers of a High-Speed Starter/Generator
Antonino La Rocca, Peter H. Connor, Zeyuan Xu, Carol N. Eastwick, Stephen J. Pickering, Christopher Gerada
University of Nottingham, UK

3:35 pm–4:00 pm
Scalability of SPM Bearingless High – Speed Motor for 180–280 kW Applications
Daria Kepsu, Rafal P. Jastrzebski, Olli Pyrhönen, Emil Kurvinen
Lappeenranta-Lahti University of Technology, Finland
4:00 pm–4:25 pm
**Acoustic Modeling and Prediction of Ultra-high Speed Switched Reluctance Machines Based on Finite Element Analysis**
Cheng Gong¹, Sufei Li², Thomas Habetler¹, Ping Zhou²
¹Georgia Institute of Technology, USA; ²ANSYS Inc., USA

3:10 pm–4:50 pm
**Control of Grid Connected Applications**
Sessions Chairs: Nuh Erdogan; Zhiwei Zhang

3:10 pm–3:35 pm
**Decoupled Power Control of SEIG-WECS System Using Nonlinear Flatness-Based Controller**
Adnan Osmanovic, Šemsudin Mašić, Jasmin Velagić
University of Sarajevo, Bosnia and Herzegovina

3:35 pm–4:00 pm
**An Intelligent Grid Integrated Solar PV Powered RSM Drive Based Water Pumping System**
Anshul Varshney, Utkarsh Sharma, Bhim Singh
Indian Institute of Technology Delhi, India

4:00 pm–4:25 pm
**MHE-MPC Based Control Architecture of an LCL Filter Grid-connected PWM Inverter**
Francesco Toso, Milo De Soricellis, Paolo Gherardo Carlet, Andrea Favato, Silverio Bolognani
University of Padova, Italy

4:25 pm–4:50 pm
**Coordinated Control of the Grid-side and Machine-side Converters of D-PMSG under Unbalanced and Distorted Grid Voltage Conditions**
Shinan Wang, Hailiang Xu, Yufeng Zhang, Rende Zhao
China University of Petroleum (East China), China

3:10 pm–4:50 pm
**ROOM: PLAZA C**

3:10 pm–4:50 pm
**ROOM: PLAZA B**

3:10 pm–3:35 pm
**Powertrain Fault Diagnosis Of Manufacturing Processes By Means Of Servo Drives**
Johann Kolb, Andreas Thul, Kay Hameyer
RWTH Aachen University, Germany

3:35 pm–4:00 pm
Lijian Wu, Yuliang Guo, Xiaoyan Huang, You teng Fang, Jiaming Liu
Zhejiang University, China

4:00 pm–4:25 pm
**OrCAD PSpice implementation of a realistic three-phase PMSM model for diagnostic purposes**
Gábor Kohlrusz, István Szalay, Dénes Fodor
University of Pannonia, Hungary

3:35 pm–4:00 pm
**An Intelligent Grid Integrated Solar PV Powered RSM Drive Based Water Pumping System**
Anshul Varshney, Utkarsh Sharma, Bhim Singh
Indian Institute of Technology Delhi, India

4:00 pm–4:25 pm
**MHE-MPC Based Control Architecture of an LCL Filter Grid-connected PWM Inverter**
Francesco Toso, Milo De Soricellis, Paolo Gherardo Carlet, Andrea Favato, Silverio Bolognani
University of Padova, Italy

4:25 pm–4:50 pm
**Coordinated Control of the Grid-side and Machine-side Converters of D-PMSG under Unbalanced and Distorted Grid Voltage Conditions**
Shinan Wang, Hailiang Xu, Yufeng Zhang, Rende Zhao
China University of Petroleum (East China), China

3:10 pm–4:50 pm
**ROOM: SIERRA A**

3:10 pm–3:35 pm
**Virtual Third Harmonic Back-EMF Based Sensorless Drive for High Speed BLDC Motors Considering Machine Parameter Asymmetries**
Lei Yang¹, Z.Q. Zhu¹, Hong Bin², Zhuya Zhang²
¹The University of Sheffield, UK; ²Midea Group Corporate Research Center, China

3:35 pm–4:00 pm
**Simple Mechanical Rotor Position Estimation Method based on Rotor Eccentricity**
Ximeng Wu, Zi-Qiang Zhu
The University of Sheffield, UK
MONDAY: SESSIONS

4:00 pm–4:25 pm
Sensorless Control of Synchronous Reluctance Motor Drives: Improved Modeling and Analysis beyond Active Flux
Anantaram Varatharajan, Gianmario Pellegrino
Politecnico di Torino, Italy

4:25 pm–4:50 pm
Optimal Load Angle Learning Algorithm for Sensorless Closed-loop Stepping Motor Control
Jasper De Vlaene¹,², David Ceulemans², Stijn Derammelaere², Kurt Stockman¹
¹Ghent University, Belgium; ²University of Antwerp, Belgium

3:10 pm–4:50 pm
ROOM: SIERRA B
PM / Synchronous Reluctance Machines
Sessions Chairs: Claudio Bianchini; Qinfen Lu

3:10 pm–3:35 pm
The Influence of the Rotor Geometry on Synchronous Reluctance Machine Vibration
Emanuel Castagnaro, Nicola Bianchi
University of Padova, Italy

3:35 pm–4:00 pm
Bonded Magnets in PM-Assisted Synchronous Reluctance Machines: Performance Dependence on the Production Technology
Emir Pošković¹,², Cristian Babetto¹, Nicola Bianchi¹, Luca Ferraris²
¹Università degli Studi di Padova, Italy; ²Politecnico di Torino, Italy

4:00 pm–4:25 pm
Assessment of Synchronous Reluctance Motor Design Using FEM-Circuit Model Considering Cross Magnetic Saturation
Mohamed SA. Shalaby, Ahmed A. Huzayyin, Khairy F. Farahat
Cairo University, Egypt

3:10 pm–4:50 pm
ROOM: SANTA FE
Machine Modeling
Sessions Chairs: Wei Xu; Kevin Lee

3:10 pm–3:35 pm
Improvements on Hybrid Analytical Modeling by Using Fourier Subdomains in Slot Regions
Christian Heister, Markus Henke
TU Braunschweig, Germany

3:35 pm–4:00 pm
End-Windings Influence in the Transient Voltage Distribution in Electrical Machine Windings Using Finite Elements Method
Rodrigo Sousa Ferreira, Antônio Carlos Ferreira
Universidade Federal do Rio de Janeiro, Brazil; TU Braunschweig, Germany

4:00 pm–4:25 pm
Analysis and Design of Electric Machines Using 2D Method of Moments
Daniel C. Horvath¹, Steven D. Pekarek¹, Ross A. Howard²
¹Purdue University, USA; ²PC Krause & Associates, USA

4:25 pm–4:50 pm
Reduction of Third Harmonic By Redesign of Magnetic Circuit in a Magnetically Geared Permanent Magnet Generator
Anders Byrdal Kjaer, Steffen Korsgaard, Simon Staal Nielsen, Peter Omand Rasmussen
Aalborg University, Denmark

4:25 pm–4:50 pm
Space Mapping–Based Fractional Horsepower Permanent Magnet Motor Design
Hannes Gruebler, Felix Krall, Stefan Leitner, Annette Muetze
Graz University of Technology, Austria
INDUSTRY RAP SESSION

4:50 pm–6:20 pm
San Diego Ballroom

Hybrid Electric Propulsion for Aerospace

Waleed Said, PhD, Chief Technology Officer, Zunum Aero

Ed Lovelace, PhD, Technical Fellow – High Power Electrical Systems, Aurora Flight Sciences, A Boeing Company

Todd Spierling, Chief Engineer, Advanced Technologies, Collins Aerospace

Luciano Serra, Head of Certification, magniX
Plenary Session #3: Integrated Motor Compressor: A System Approach

Wolfgang Faller, PhD, Solar Turbines, Inc., Gas Compressor Business

Solar Turbines is a manufacturer of gas turbines and centrifugal gas compressors, predominantly used in power generation and oil and gas production and transmission applications. To compress gas in a centrifugal gas compressor, mechanical drive power is provided either by a gas turbine (the speed of that turbine is matched to the compressor speed) or by an electric motor. Usually, low-speed motors (2 or 4 pole motors) are used together with a speed increased gearbox. A variable frequency drive (VFD) provides the controllability to adjust speed and therefore create the desired gas flow and discharge pressure to the connected plant. This session will lay out some of the trade-off considerations that must be optimized to achieve a robust product, easy to service and maintain, all at a price level that makes the overall business case viable driven by two major mega-trends: decarbonization and emission with a solution comprising of a high-speed electrical motor connected to the compressor rotor, all supported on active magnetic bearings (AMB) inside of a pressure vessel. Advantages of this technology will be presented with a few hurdles that require careful consideration along with an overall cost perspective.

ORAL SESSIONS

8:40 am–9:55 am
ROOM: PLAZA A

Magnetic Bearings
Sessions Chairs: Eric Severson; Emil Kurvinen

8:40 am–9:05 am
Control of Rotors Suspended on Low-Cost Active Magnetic Bearings
Seamus D. Garvey¹, Graham Johnson¹, Stephen Pearson¹, Karuna Kalita¹, Gareth Moore¹, Antony Kirk¹
¹The University of Nottingham, UK; ²Rolls-Royce plc, UK
8:40 am–9:55 am
ROOM: PLAZA C

Grid quality
Sessions Chairs: Adnan Osmanovic; Gianmario Pellegrino

8:40 am–9:05 am
Generator Back- Electromotive-Force Shaping for DC Output with Low Ripple Voltage
Qichen Jin, Phuc Huynh, Anijit Banerjee
University of Illinois Urbana-Champaign, USA

9:05 am–9:30 am
Coupling Transformer Operation of a Dynamic Voltage Restorer with Electronics Protected from Fault Currents Under Electrical Grid Conditions
Hervé Roisse, Guillaume Parent, Mathieu Rossi, Virginie Majchrzak
University of Artois, France

9:30 am–9:55 am
Impacts of DFIG-Based Wind Power System on Migration Mechanism of Oscillation Center
Fei Tang¹, Jiale Liu¹, Dichen Liu¹, Fusuo Liu², Weiqiang Liang¹, Feifei Wang¹
¹Wuhan University, China; ²North China Electric Power University, China

8:40 am–9:55 am
ROOM: SIERRA A

Control of Electrical Drives (II)
Sessions Chairs: Keiichiro Kondo; Shanelle Foster

8:40 am–9:05 am
Module Connection Topologies and Interleaving Strategies for Integrated Modular Motor Drives
Lynn Verkroost, Jordi Van Damme, Hendrik Vansompel, Frederik De Belie, Peter Sergeant
Ghent University, Belgium

9:05 am–9:30 am
Modeling and Simulation of Switched Reluctance Machines for Control and Estimation Tasks
Prerit Pramod¹, Prathima Null², Rakesh Mitra¹, Siddharth Mehta²
¹Nexteer Automotive Corp., USA; ²North Carolina State University, USA

9:30 am–9:55 am
Optimal Loop-Shaping of Position Controls of Feed in Machine Tools with Position-Dependent Behavior
Sebastian Kehne, Thomas Berners, Alexander Eppe, Christian Brecher
RWTH Aachen University, Germany

8:40 am–9:55 am
ROOM: SIERRA B

Switched Reluctance Machines
Sessions Chairs: Bilal Akin; Iqbal Husain

8:40 am–9:05 am
Analytical and Experimental Verification of Novel Current Waveforms for Noise Reduction in Switched Reluctance Motor
Jihad Furqani¹, Candra Adi Wiguna¹, Akira Chiba¹, Omer Gundogmus², Mohammed Elamir², Yilmaz Sozer²
¹Tokyo Institute of Technology, Japan; ²University of Akron, USA

9:05 am–9:30 am
Switched Reluctance Machine Peak and Continuous Performance using a Routine Optimized Tool
Sara Roggia¹, Yew Chuan Chong¹, Yaohui Gai², Mircea Popescu², Dave Staton³, James Goss³
¹Safran Tech, France; ²Motor Design Ltd., UK

9:30 am–9:55 am
On the Effects of Mechanical Offset Between Inner and Outer Stator in Double Stator Switched Reluctance Machines
Colbey Hair, Amir Parsapour, Medhi Moallem, Babak Fahimi
The University of Texas at Dallas, USA

8:40 am–9:55 am
ROOM: SANTA FE

Machine Modeling and Optimization
Sessions Chairs: Giuseppe Volpe; Ziaur Rahman

8:40 am–9:05 am
An HPC-Based Data-Driven Process for Design Exploration and Optimization of Motor Drives
Vahid Ghorbanian¹, Mohammad Hossain Mohammadi¹, Issah Ibrahim¹, David Alister Lowther¹, James Hendershot²
¹McGill University, Canada; ²MotorSolver, USA
TUESDAY: SESSIONS

9:05 am–9:30 am
Design Optimization of Electric Machines with 3D FEA and a New Hybrid DOE-DE Numerical Algorithm
Narges Taran\textsuperscript{1}, Vandana Rallabandi\textsuperscript{1}, Dan M. Ione\textsuperscript{1}, Greg Heins\textsuperscript{2}, Dean Patterson\textsuperscript{2}, Ping Zhou\textsuperscript{1}
\textsuperscript{1}University of Kentucky, USA; \textsuperscript{2}Regal Beloit Corp., Australia; \textsuperscript{3}ANSYS, Inc., USA

9:30 am–9:55 am
Design Optimization of Interior Permanent Magnet Synchronous Machines Utilizing Global Response Surface Method for Variable Speed Drives
Mazharul Chowdhury\textsuperscript{1}, Md Sariful Islam\textsuperscript{2}, Mohammad Islam\textsuperscript{1}
\textsuperscript{1}Halla Mechatronics, USA; \textsuperscript{2}North Carolina State University, USA

1:00 pm–2:40 pm
ROOM: PLAZA A

Electric Machine Design Optimizations for Transportation Applications
Sessions Chairs: Omer Gundogmus; Zhentao Du

1:00 pm–1:25 pm
Optimal Design of 2nd Generation TMED HEV Traction Motor
Sang-Hwa Do, Kyoung-Bum Kim, Jae-Bum Park, Nyeon-Han Hong, Hye-Ra Lee
Hyundai Motor Company, Korea (South)

1:25 pm–1:50 pm
Design and Optimization of a PMASR motor for Low-Voltage E-Scooter Applications
Cristian Babetto\textsuperscript{1}, Nicola Bianchi\textsuperscript{1}, Giorgio Benedetti\textsuperscript{2}
\textsuperscript{1}University of Padova, Italy; \textsuperscript{2}Askoll Holding s.r.l., Italy

1:50 pm–2:15 pm
Design Analysis of a High-Speed Copper Rotor Induction Motor for a Traction Application
Nicolas Riviere\textsuperscript{1}, Giuseppe Volpe\textsuperscript{1}, Marco Villani\textsuperscript{1}, Giuseppe Fabri\textsuperscript{1}, Lino Di Leonardo\textsuperscript{2}, Mircea Popescu\textsuperscript{1}
\textsuperscript{1}Motor Design Ltd., UK; \textsuperscript{2}University of l’Aquila, Italy

2:15 pm–2:40 pm
Comparison Between Two Conical Induction Machines Designed for an Electric Vehicle Application
Uğur Demir\textsuperscript{1}, Sara Roggia\textsuperscript{2}, Mustafa Caner Aküner\textsuperscript{3}
\textsuperscript{1}Coşkunöz Holding A.Ş., Turkey; \textsuperscript{2}SAFRAN, France; \textsuperscript{3}Marmara University, Turkey

1:00 pm–2:40 pm
ROOM: PLAZA B

Thermal Management of Electrical Machines
Sessions Chairs: Sabrina Ayat; Guang-Jin Li

1:00 pm–1:25 pm
Effects of Annealing on Magnetic Properties of Laminated Stator Cores and Efficiency of Induction Machines
Patrick Breining\textsuperscript{1}, Abdullah Kahveci\textsuperscript{2}, Martin Doppelbauer\textsuperscript{2}
\textsuperscript{1}Karlsruhe Institute of Technology, Germany; \textsuperscript{2}Thyssenkrupp Steel Europe AG, Germany

1:25 pm–1:50 pm
Binder Jet Printed Iron Silicon with Low Hysteresis Loss
Thang Q. Pham\textsuperscript{1}, Christiane Mellak\textsuperscript{2}, Hawke Suen\textsuperscript{1}, Carl J. Boehlert\textsuperscript{1}, Annette Muetze\textsuperscript{2}, Patrick Kwon\textsuperscript{1}, Shanelle N. Foster\textsuperscript{1}
\textsuperscript{1}Michigan State University, USA; \textsuperscript{2}Graz University of Technology, Austria

1:50 pm–2:15 pm
AC Winding Loss Reduction in High Speed Axial Flux Permanent Magnet Machines using a Lamination Steel Sheet
N. Aliyu, N. Ahmed, N. Stannard, G.J. Atkinson
Newcastle University, UK

2:15 pm–2:40 pm
Magnetization Characteristics and Loss Measurements in the Axial Flux Permanent Motor’s Stator
Qurban Ali Shah Syed, Veronika Solovieva, Ingo Hahn
University of Erlangen-Nuremberg, Germany

1:00 pm–2:40 pm
ROOM: PLAZA C

Special Machines
Sessions Chairs: Chris Gerada; Ayman El-Refaie

1:00 pm–1:25 pm
Loss Breakdown of a Dual Conical Rotor Permanent Magnet Motor using Grain Oriented Electrical Steel and Soft Magnetic Composites
Matthew C. Gardner\textsuperscript{1}, Yichi Zhang\textsuperscript{1}, Dorsa Talebi\textsuperscript{1}, Hamid A. Toliyatat\textsuperscript{1}, Alan Crapo\textsuperscript{2}, Paul Knauer\textsuperscript{2}, Harold Willis\textsuperscript{2}
\textsuperscript{1}Texas A&M University, USA; \textsuperscript{2}Regal Beloit Corporation, USA
1:25 pm–1:50 pm
Design and Analysis of Interior Permanent Magnet Two Degrees of Freedom Motor Based on Cross-Coupled Structure
Yoshiyuki Hatta, Tomoyuki Shimono, Yasutaka Fujimoto
Yokohama National University, Japan

1:50 pm–2:15 pm
A Novel Contactless Rotary-to-Linear Magnetic Actuator
Hussain A. Hussain
Kuwait University, Kuwait

2:15 pm–2:40 pm
Single-Phase Open-Circuit Fault Operation of Bearingless Multi-Sector PM Machines
Zhuang Wen, Giorgio Valente, Andrea Formentini, Luca Papini, Pericle Zanchetta, Christopher Gerada
University of Nottingham, UK

1:00 pm–2:40 pm
ROOM: SIERRA A

PM Motor Drives
Sessions Chairs: Jiangbiao He; Maher Al-Badri

1:00 pm–1:25 pm
A Novel Rotor Initial Position Detection Method Utilizing DC-link Voltage Sensor
Ximeng Wu, Zi-Qiang Zhu
The University of Sheffield, UK

1:25 pm–1:50 pm
Low Inductance Effects on Electric Drives Using Slotless Permanent Magnet Motors: A Framework for Performance Analysis
Matteo Leandro¹, Nicola Bianchi², Marta Molinas², Ravindra Babu Ummanneni³
¹University of Padova, Italy; ²Norwegian University of Science and Technology, Norway; ³Alva Motor Solutions, Norway

1:50 pm–2:15 pm
Modeling, Analysis and Compensation of Resistance Imbalance in Permanent Magnet Synchronous Motor Drives for Mass Manufacturing Applications
Prerit Pramod, Aparna Saha, Krishna Namburi, Rakesh Mitra
Nexteer Automotive Corp., USA

2:15 pm–2:40 pm
Comparative Performance Evaluation of Hall Effect Sensorless Control Options in Permanent Magnet Brushless DC Motor Drives
Kevin Lee¹, Feilang Li², Wenxi Yao²
¹Eaton Corp., USA; ²Zhejiang University, China

1:00 pm–2:40 pm
ROOM: SIERRA B

Machine Vibrations
Sessions Chairs: Bilal Akin; Iqbal Husain

1:00 pm–1:25 pm
On the Use of Vibration Synthesis to Ease Electric Machine Powertrain Design
F. Chauvicourt, S. Ciceo, H. Van der Auweraer
Siemens Industry Software NV, Belgium

1:25 pm–1:50 pm
A Method of Modal Parameter Estimation Based on an Electromagnetic Vibration Exciter
Jianfeng Hong, Shanming Wang, Yuguang Sun, Haixiang Cao
Tsinghua University, China

1:50 pm–2:15 pm
Acoustic Noise and Vibration in Switched Reluctance Machines: A Comparative Study of 12/8 and 8/6 Topologies
Selin Yaman, Chengxiu Chen, Ziyan Zhang, Mahesh Krishnamurthy
Illinois Institute of Technology, USA

2:15 pm–2:40 pm
Experimental and Simulation Based Study of Vibration Reduction Techniques in Fractional Slot Permanent Magnet Synchronous Machines
Shuvajit Das¹, Anik Chowdhury¹, Subhra Paul², Zhao Wan³, Rakib Islam⁴, Yilmaz Sozer⁵
¹University of Akron, USA; ²Nexteer Automotive, USA; ³DURA Automotive Systems, USA
1:00 pm–2:40 pm
ROOM: SANTA FE

Machines – Numerical Modeling
Sessions Chairs: Qinfen Lu; Giuseppe Volpe

1:00 pm–1:25 pm
Numerical Calculation of End-Coil’s Leakage Inductance for Concentrated and Hairpin Windings
Shuvajit Das¹, Anik Chowdhury¹, Subhra Paul², Zhao Wan³, Rakib Islam⁴, Yilmaz Sozer⁵
¹University of Akron, USA; ²Nexteer Automotive, USA; ³DURA Automotive Systems, USA

1:25 pm–1:50 pm
On the Numerical Transient in Time-Stepping Finite Element Analysis of Induction Motors:
Fundamental Concepts
Hossein Nejadi Koti, Hao Chen, Yue Sun, Nabeel A.O. Demerdash
Marquette University, USA

1:50 pm–2:15 pm
On Shortening the Numerical Transient in Time-Stepping Finite Element Analysis of Induction Motors:
Method Implementation
Hossein Nejadi Koti, Hao Chen, Yue Sun, Nabeel A.O. Demerdash
Marquette University, USA

2:15 pm–2:40 pm
Optimal Design of Cooling Fan for 200kW Class Low Voltage Motor by Numerical Analysis
Chungman Jang, Jongin Lee, Minkyu Sung, Joonyeob Lee
Hyundai Electric & Energy Systems Co., Ltd., Korea (South)

3:10 pm–4:50 pm
ROOM: PLAZA B

Thermal Design of Electrical Machines
Sessions Chairs: Michael Galea; Shafigh Nategh

3:10 pm–3:35 pm
The Use of Phase Change Material for the Cooling of Electric Machine Windings Formed with Hollow Conductors
Sabrina Ayat¹, Camel Serghine², Thomas Klowski², Sébastien Yori³, Albert Mutabazi¹, Steven McDaniel³
¹Safran Tech, France; ²Safran Helicopter Engines, France; ³Areeles Technologies, France; ⁴Safran Electrical & Power, USA

3:35 pm–4:00 pm
Comparative Study of Three Stator Cooling Jackets for Electric Machine of Mild Hybrid Vehicle
Xiaofeng Yang, Alireza Fatemi, Thomas Nehl, Lei Hao, Wei Zeng, Scott Parrish
General Motors Global R&D Center, USA

3:35 pm–4:00 pm
Study on the Slot/Pole Combination Influences to the Thrust Performances of the Linear Permanent Magnet Vernier Machines
Chaojie Shi, Ronghai Qu, Yuting Gao
Huazhong University of Science and Technology, China

4:00 pm–4:25 pm
Computationally fast peak detent calculation for transverse flux PMLSM by multi-fidelity surrogate
Salman Ahmed⁴, Kunihiko Norizuki⁵, Yasuaki Aoyama⁶, Takafumi Koseki⁵
¹The University of Tokyo, Japan; ²Hitachi, Ltd., Japan

4:25 pm–4:50 pm
A Novel Flux Modulation Linear Machine with Dual-Sided Modular Primary and Multiple Pole Pitches
You Zhou, Ronghai Qu, Yuting Gao, Dawei Li, Chaojie Shi
Huazhong University of Science and Technology, China

3:10 pm–4:50 pm
ROOM: PLAZA A

Design of Linear Motors
Sessions Chairs: Wei Xu; Rabiu Islam

3:10 pm–3:35 pm
Thrust Ripple Reduction of PMLSM Based on Arc Shaping Technique and Taguchi Method
Fei Dong, Jiwen Zhao, Jing Zhao, Juncai Song
Anhui University, China

3:35 pm–4:00 pm
The Use of Phase Change Material for the Cooling of Electric Machine Windings Formed with Hollow Conductors
Sabrina Ayat¹, Camel Serghine², Thomas Klowski², Sébastien Yori³, Albert Mutabazi¹, Steven McDaniel³
¹Safran Tech, France; ²Safran Helicopter Engines, France; ³Areeles Technologies, France; ⁴Safran Electrical & Power, USA
4:25 pm–4:50 pm
*Air-Cooling of a Hollow High-Speed Permanent Magnet Rotor*
Peter H. Connor, Antonino La Rocca, Zeyuan Xu, Michele Degano, Carol N. Eastwick, Stephen J. Pickering, Chris Gerada
University of Nottingham, UK

3:10 pm–4:50 pm
**ROOM: PLAZA C**

**Synchronous and Reluctance Machines**
*Sessions Chairs: Glyn Attkinson; Thomas Lipo*

3:10 pm–3:35 pm
*Torque Performance Improvement of Doubly Salient Synchronous Reluctance Machines by Current Harmonic Injection*
K. Zhang, G.J. Li, Z.Q. Zhu, G.W. Jewell
The University of Sheffield, UK

3:35 pm–4:00 pm
*Design Aspects of a Novel Brushless Excitation System for Synchronous Machines*
Jan Pötter¹, Martin Pföst¹, Gernot Schullerus²
¹TU Dortmund, Germany; ²Reutlingen University, Germany

4:00 pm–4:25 pm
*A HTS Machine Concept with a Passive Rotor*
Naireeta Deb, Thomas A. Lipo, Sastry V. Pamidi
Florida State University, USA

4:25 pm–4:50 pm
*Design and Analysis of Mutually Coupled SRMs for Low Torque Ripple Applications Using Standard Voltage Source Inverters*
Siddharth Mehta¹, Md Ashfanoor Kabir², Iqbal Husain³
¹North Carolina State University, USA; ²ABB Inc., USA

3:10 pm–4:50 pm
**ROOM: SIERRA B**

**Permanent Magnet Machines-3**
*Sessions Chairs: Edmund Marth; Gerald Jungmayr*

3:10 pm–3:35 pm
*Improved Stator/Rotor-Pole Number Combinations for Torque Ripple Reduction in Doubly Salient PM Machines*
Lijian Wu, Guangqiang Ming, Liu Zhang, You tong Fang
Zhejiang University, China

3:35 pm–4:00 pm
*Robust Design Approach of Permanent Magnet Synchronous Motors for Torque Ripple Minimization*
Subhra Paul, David Harris, Zhao Wan, Jeff Klass
Nexteer Automotive, USA

4:00 pm–4:25 pm
*Computationally Efficient Design Procedure for Single-Layer IPM Machines*
Simone Ferrari¹, Gianmarco Pellegrino², Mohamed Zubair M. Jaffar³, Iqbal Husain⁴
¹Politecnico di Torino, Italy; ²North Carolina State University, USA
TUESDAY: SESSIONS

4:25 pm–4:50 pm
Design and Experimental Evaluation of a High Specific Power Permanent Magnet Synchronous Machine
Longya Xu, Hongyu Wang, Han Xiong, Ziwei Ke, Julius Woo, Julia Zhang, Sheng Dong
The Ohio State University, USA

3:10 pm–4:50 pm
ROOM: SANTA FE

Permanent Magnet Machines-4
Sessions Chairs: Jiangbiao He; Kevin Lee

3:10 pm–3:35 pm
Lower-Cost Interior Permanent Magnet Machine with a Blend of Magnet Types
Qingqing Ma, Ayman EL-Refaie, Bruno Lequesne
Marquette University, USA

3:35 pm–4:00 pm
Comparison of Inner and Outer Rotor Configurations in Slotless PM Machines with PCB Windings
Nicolas Verbeek, Bruno Dehez
Université Catholique de Louvain, Belgium

4:00 pm–4:25 pm
Novel Rotor Design with Reduced Rare-Earth Material for PM Machines
G. Dajaku1, H. Zhou1, X. Dajaku1, D. Gerling2
1FEAM GmbH, Germany; 2Bundeswehr University Munich, Germany

4:25 pm–4:50 pm
Analytically Determined Graph Based Solution for Minimum Cogging in SPM Motors with Integer Slots Per Pole
Naveen Kumar Endla
Indian Institute of Technology Gandhinagar, India

POSTER SESSIONS

Poster Session #1 | 10:30 am–12:00 pm
Rotating Electric Machines
Sessions Chairs: Wei Xu; Chushan Li

Study of Manufacturing Defect of Modular Permanent Magnet Machines: Segment RadialDisplacement
B. Ren, G.J. Li, Z.Q. Zhu, M.P. Foster, D.A. Stone
The University of Sheffield, UK

Magnetic Circuit Analysis of the Low-Cost In-Wheel Switching Flux Motor for HEV Applications
Oleksandr Dobzhanskyi1, Rupert Gouws2
1Oregon Institute of Technology, USA; 2North-West Universities, South Africa

Neural Network Meta-Modeling and Optimization of Flux Switching Machines
Haris Kurtović, Ingo Hahn
Friedrich-Alexander University of Erlangen-Nuremberg, Germany

Concept of a Small Permanent Magnet Motor with External Spur Gear Rotor and High Torque Density
Jonathan Terfurth, Nejila Parspour
University of Stuttgart, Germany

High-Torque Low-Speed Permanent Magnet Assisted Synchronous Reluctance Motor Design
Giacomo Bacco1, Nicola Bianchi1, Fabio Luise2
1University of Padova, Italy; 2Nidec-ASI SpA, Italy

An Analysis of Ferrite Magnet Assisted Synchronous Reluctance Machines for Low Power Drives including Flux Weakening
Matthias Hofer, Manfred Schrödl
Technische Universität Wien, Austria

Optimization of Additively Manufactured Permanent Magnets for Wind Turbine Generators
Connor McGarry, Alasdair McDonald, Nasser Alotaibi
University of Strathclyde, UK

High Torque Density Double Stator Permanent Magnet Electric Machine
Amir Parsapour1, Mehdi Moallem1, Ion Boldea2, Babak Fahimi3
1The University of Texas at Dallas, USA; 2Technical University of Timisoara, Romania

Detection of Static Eccentricity on Multi-Three-Phase Permanent Magnet Synchronous Motors by the Harmonic of No-Lead Stator Voltages
Kodai Okazaki1, Yoshihiro Miyama1, Kan Akatsu2
1Mitsubishi Electric Co., Ltd., Japan; 2Shibaura Institute of Technology, Japan

Synthesis of Novel Flux Modulation Machine with Permanent Magnets on Both Stator and Rotor
Yuting Gao, Dawei Li, Ronghai Qu, Han Ding
Huazhong University of Science and Technology, China
Design and Analysis of Aligned Axis Interior Permanent Magnet Machines Considering Saturation
Steven Hayslett, Elias Strangas
Michigan State University, USA

Analytical Design of Permanent Magnet Machines with Air-gap Winding
Junquan Lai, Jian Li
Huazhong University of Science and Technology, China

Split Rotor for Permanent Magnet Electrical Machines
Mehmet C. Kulan¹, Nick J. Baker², Simon Turvey²
¹Newcastle University, UK; ²Rolls – Royce Plc., UK

Comparative Study on Vibration Behaviors of Permanent Magnet Assisted Synchronous Reluctance Machines with Different Rotor Topologies
Yang Lu, Jian Li, Hongwei Xu, Ronghai Qu, Jianbo Sun
Huazhong University of Science and Technology, China

Reduction Methods using Canceling Effect for Cogging Torque in Dual-Stator PM Synchronous Machines
Ying Meng¹, Kaiyuan Lu¹, Lijian Wu², Hao Yin²
¹Aalborg University, Denmark; ²Zhejiang University, China

Comparison of Halbach Rotors with Other PM Structures
Pia Lindh¹, Ilya Petrov², Juha Pyrhönen¹, Timo Santa-Nokki²
¹Lappeenranta University of Technology, Finland; ²Prizztech Ltd., Finland

Asymmetric Rotor Surface Design in Interior Permanent Magnet Synchronous Motors for Torque Ripple Mitigation
Jingchen Liang, Amir Parsapour, Mehdi Moallem, Babak Fahimi
The University of Texas at Dallas, USA

A Sleeve-Free Interior Permanent Magnet High Speed Motor With Non-Uniform Airgap
Hongwei Xu, Jian Li
Huazhong University of Science and Technology, China

Analysis of PM Machines with Sectored-Stator
Mostafa Ahmadi Darmani¹, Gerd Bramerdorfer², Silvio Vaschetto¹, Andrea Cavagnino¹, Stefano Carabelli¹
¹Politecnico di Torino, Italy; ²Johannes Kepler University Linz, Austria

Simplified Analytical Machine Sizing for Surface Mounted Permanent Magnet Machines
Patrick Xie, Ramkumar Ramanathan, Gaurang Vakil, Chris Gerada
University of Nottingham, UK

Influence of Load Characteristics on Three-Phase Short Circuit and Demagnetization of Surface-Mounted Permanent Magnet Synchronous Motor
Lijian Wu, Yidong Du, Youtong Fang
Zhejiang University, China

Development of a Consequent Pole PM type Axial-Gap Motor with DC Field Winding
Tomohira Takahashi¹, Masatsugu Takemoto², Satoshi Ogasawara², Toru Ogawa¹, Hideaki Arita¹, Akhiro Daikoku¹
¹Mitsubishi Electric Corp., Japan; ²Hokkaido University, Japan

High-Speed Motors, Bearingless Motors, and Magnetic Bearings
Sessions Chairs: Wolfgang Gruber; Emil Kurvinen

Homopolar Active Magnetic Bearing Design for Outer Rotor Kinetic Energy Storages
Daniel Franz, Michael Richter, Maximilian Schneider, Stephan Rinderknecht
Technische Universität Darmstadt, Germany

Design and Analysis of a Bearingless Motor With Passive Axial Suspension Through Null-Flux Coils
Guilherme Cavalcante Rubio, Akira Chiba
Tokyo Institute of Technology, Japan

Impact of Digital Signal Processing on FOC Current Feedback in High-Speed PMSM Drive
Leszek Jarzebowicz¹, Miroslav Gutten²
¹Gdansk University of Technology, Poland; ²University of Zilina, Slovak

High Speed Permanent Magnet Synchronous Machine Drive under Insufficient Sample Frequency
Wen-Chuan Chen, Shih-Chin Yang, Po-Huan Chou, Yu-Liang Hsu, Jyun-You Chen, Guan-Ren Chen, Chin-Sheng Chen
Non-axisymmetric Structural Analysis of High Speed Rotor Retention Sleeve
Vinicius Cabral do Nascimento, Scott D. Sudhoff
Purdue University, USA

Design, Modelling and Control of MIMO AMB System with 3 Radial Bearing Planes for Megawatt-Range High-Speed Rotor
Rafal P. Jastrzębski, Emil Kurvinen, Olli Pyrhönen
Lappeenranta-Lahti University of Technology, Finland

Experimental Characterization of Tilt Stabilization within Passively Levitated Electrodynamic Thrust Self-Bearing Motor
Joachim Van Verdegem, Bruno Dehez
Université Catholique de Louvain, Belgium

Comparison of the Performance of Different Asynchronous Solid-Rotor Constructions in a Megawatt-Range High-Speed Induction Motor
Emil Kurvinen, Chong Di, Ilya Petrov, Rafal P. Jastrzębski, Daria Kepsu, Juha Pyrhönen
Lappeenranta-Lahti University of Technology, Finland

Integrated Multiport Conversion with Rotating Transformer
Richard Liou, Seth Sanders
University of California, Berkeley, USA

Proposal of an Axial Gap Type Single-drive Bearingless Reluctance Motor
Hiroti Higashi, Kyohei Kyota, Kenji Amei, Takahisa Ohji
University of Toyama, Japan

Magnetic-Geared Motor in Side-by-Side Arrangement – Optimization
Edmund Marth1, Gerald Jungmayer2, Wolfgang Amrhein1
Frank Jeske1
1Johannes Kepler University Linz, Austria; 2Linz Center of Mechatronics GmbH, Austria;
EBM-Papst St. Georgen GmbH & Co. KG, Germany

Magnetic-Geared Motor in Side-by-Side Arrangement – Concept and Design
Gerald Jungmayer1, Edmund Marth1, Gordan Segon3
1Linz Center of Mechatronics GmbH, Austria; 3Johannes Kepler University Linz, Austria

Active Compensation of the Deformation of a Magnetically Levitated Mover of a Planar Motor
C.H.H.M. Custers1, I. Proimadis1, J.W. Jansen2, H. Butler1, R. Töth1, E.A. Lomonova1, P.M.J. van den Hof2
1Eindhoven University of Technology, The Netherlands; 2Prodrive Technologies B.V., The Netherlands

Analytical Estimation of Eddy Current Losses in PCB Windings for the Optimal Sizing of PM Slotless Motors
Guillaume François, François Baudart, Bruno Dehez
Université Catholique de Louvain, Belgium

Improved 1-D Model for Semi-Hard Magnetic Material-Based Electromagnets
Salvatore Circosta, Renato Galluzzi, Nicola Amati, Angelo Bonfitto, Luis M. Castellanos Molina, Andrea Tonoli
Politecnico di Torino, Italy

H-Infinity Control of Dual Motor Bearingless Machine
Pekko Jaatinen, Niko Nevaranta, Jouni Vuojolainen, Rafal Jastrzębski, Olli Pyrhönen
Lappeenranta-Lahti University of Technology, Finland

Active Vibration Control of a Flexible Rotor in Magnetically Suspended High-Speed Motor to Pass the First Bending Critical Speed with Optimal Phase Compensation Control
Feng Cao, Changsheng Zhu
Zhejiang University, China

Noise Reduction Topology for Concentrate Winding High BLDC motors
Batiste Galmès, Gilles Tonnelier, Jean-Daniel Alzingre, Christophe Espanet
Moving Magnet Technologies SA, France

Condition Monitoring
Sessions Chairs: Hui Yang; Ziaur Rahman

Position Estimation of Outer Rotor PMSM Using Linear Hall Effect Sensors and Neural Networks
Yuyao Wang, Yovahn Hoole, Kiruba Haran
University of Illinois Urbana-Champaign, USA

Predictive Diagnostic Based on HF Modeling of Electrical Machines Windings
Mustapha Toudji, Stéphane Duchesne, Guillaume Parent
University of Artois, France

Fault Diagnosis in Three-Phase Power Inverters Using Multiple-Model Kalman Filter
S. Mohsen Azizi
New Jersey Institute of Technology, USA
Hybrid Fault Detection in Power Electronic Systems
Nikola Markovic, Thomas Stoetzel, Volker Staudt,
Dorothea Kolossa
Ruhr University Bochum, Germany

Comparison of Failure Modes, Effect Analysis and Reliability of Electric Machine Drives
Omer Gundogmus¹, Salman Harasis¹, Sifat M. Chowdhury¹,
Lavanya Vadomodala¹, Shuvajit Das¹, Ehsanal Haque¹,
Yilmaz Sozer¹, Fernando Venegas⁶, David Colavincenzo²
¹University of Akron, USA; ²Bendix Commercial Vehicle Systems, USA

Saliency-Based Self-Sensing Enhanced Operating Condition Monitoring Using High-Frequency Injection Under Intentional Magnetic Saturation
Ye gu Kang, Bulent Sarlioglu, Robert D. Lorenz
University of Wisconsin-Madison, USA

Validation and Verification of a Structural Mechanical Stator End-Winding Region Model
Sebastian Lange, Martin Pfost
TU Dortmund University, Germany

Troubles with Insulation Design and Reliability in Motors Fed by PWM Due to Increase of Switch Slew Rate and Operating Voltage?
Gian Carlo Montanari³, Robert Hebner¹, Paolo Seri³,
Riddhi Ghosh²
³University of Texas at Austin, USA; ²DEI, University of Bologna, Italy

Improved Sensorless Control for Permanent-Magnet Synchronous Motor with Inductance Asymmetry
Mingwei Xu, Lijian Wu, Xiaoyan Huang, Youtong Fang, Jiaming Liu
Zhejiang University, China

Analysis Guideline to Determine Capabilities of IPM Motors for Automotive Application
Grazia Berardi, Michele Bonfante, Nicola Bianchi
University of Padova, Italy

Analysis of a Rare Earth-Free Dual Mechanical Port Machine with PM-Assisted Reluctance Rotor for Hybrid Electric Vehicles
Zhiwei Zhang
The Ohio State University, USA

Optimized Sizing of IPM Machines for Automotive Traction Applications
Giorgio Valente¹, David Gerada¹, Michele Degano¹,
Christopher Gerada¹, John Foulsham², Daniel Beeby²
¹University of Nottingham, UK; ²GKN ePowertrain, UK

An Air-Cooled YASA Motor for In-Wheel Electric Vehicle Applications
Dave Winterborne¹, Nick Stannard¹, Lars Sjöberg²,
Glynn Atkinson¹
¹Newcastle University, UK; ²Höganäs AB, Sweden

Impact Study of Isolated and Correlated Manufacturing Tolerances of a Permanent Magnet Synchronous Machine for Traction Drives
Christoph Mülder¹, Marius Franck¹, Michael Schröder¹,
Markus Balluff, Andreas Wanke², Kay Hameyer¹
¹RWTH Aachen University, Germany; ²Daimler AG, Germany

Evaluation of Fractional Slot Concentrated Winding Permanent Magnet Synchronous Machine for Electric Vehicle Application
Anqing He¹, Chenxi Zhou², Xiaoyan Huang³, Jianxin Shen¹,
Youtong Fang⁴, Qinfen Lu⁵
¹Zhejiang CRRC Electric Vehicle Co. Ltd., China; ²Zhejiang University, China

Sizing, Design, and Modelling of Aerospace Electric Drive System with Long Feeder Cables
Patrick Xie, Gaurang Vakil, Chris Gerada
University of Nottingham, UK

Multi-Physics Design and Optimization for a SPM Machine with MnBi Magnet and 6.5% Silicon Steel Materials for Traction Applications
Zhentao Stephen Du, Jagadeesh Tangudu, Aritra Sur,
Sunil Soni
United Technologies Research Center, USA
TUESDAY: SESSIONS

INDUSTRY RAP SESSION

4:50 pm–6:20 pm
San Diego Ballroom

Thermal Management for Electrical Applications

Michael Ohadi, PhD, Program Director, US DOE
Advanced Research Projects Agency – Energy (ARPA-E)

Charles Lents, Associate Director, Research, United
Technologies Research Center

Kevin Bennion, Research Engineer, Transportation and
Hydrogen Systems Center, National Renewable
Energy Laboratory
WEDNESDAY: SESSIONS

PLENARY SESSION

8:00 am–8:40 am

Location

Plenary Session #4: Advanced Mechatronics and Control for Precision Motion Control
Tsu-Chin Tsao, PhD, Professor, Mechanical and Aerospace Engineering, Henry Samueli School of Engineering and Applied Science, University of California Los Angeles

Mechanical motion generation and vibration suppression are fundamental to numerous modern electric machines and emerging innovations. Common control methods such as the PID control are ineffective for complex dynamic systems. Enabled by advanced control algorithms, increasing computing power, and the emergence of real-time system prototyping tools. An overview of high-performance electric machines enabled by advanced mechatronics and control will be presented. These include applications in complex geometry metal cutting, nano-precision scanning lithography, computer hard disk drives, laser beam steering, active magnetic bearings, robotic surgery, and etc.

ORAL SESSIONS

8:40 am–9:55 am

ROOM: PLAZA A

Control of Linear Motor Drives and Applications
Sessions Chairs: Wei Xu; Rabiul Islam

8:40 am–9:05 am
Disturbance Attenuation and Response Time Improvement of Permanent Magnet Synchronous Linear Motor by Using Robust Predictive Resonant Current Control
Jiwen Zhao, Lijun Wang, Zhongyan He, Juncal Song
Anhui University, China

9:05 am–9:30 am
A Sensorless Finite-Set Model Predictive Direct Thrust Control of a Linear Induction Motor based on MRAS for Linear Metro
Mahmoud F. Elmoshedy¹, Wei Xu¹, Yi Liu¹, Minghai Dong²
¹Huazhong University of Science and Technology, China; ²Foshan Golden Age Motor Technology Co., Ltd., China

9:30 am–9:55 am
Control of Linear Motor Drives and Applications
Jun-Di Sun¹,², Guang-Zhong Cao¹, Su-Dan Huang¹, Qing-Quan Qian²
¹Shenzhen University, China; ²Southwest Jiaotong University, China

8:40 am–9:55 am

ROOM: PLAZA B

Multiphase Machines Analysis and Design
Sessions Chairs: Frank Scuiller; Jorge Rodas

8:40 am–9:05 am
Predicting the Space Harmonics Generated by Multi-Phase Windings
Franck Scuiller
École Navale, France

9:05 am–9:30 am
Fault Analysis for Dual Three-Phase Synchronous Reluctance Motor
Jun-Kyu Park, Cristian Babetto, Nicola Bianchi
University of Padova, Italy

9:30 am–9:55 am
Optimal Carrier Phase-Shift Angle on Dual Three-Phase Windings Permanent Magnet Synchronous Motor
Yoshihiro Miyama¹, Kan Akatsu²
¹Mitsubishi Electric Corp., Japan; ²Shibaura Institute of Technology, Japan

8:40 am–9:55 am

ROOM: PLAZA C

System Modeling and Characterization
Sessions Chairs: Guillaume Parent; Maximilian Schneider

8:40 am–9:05 am
Real-Time Hardware Emulation of a Power Take-Off Model for Grid-Connected Tidal Energy Systems
Nuh Erdogan¹, Donal B. Murray¹, Jochen Giebhardt², Matthias Wecker², James Donegan³
¹University College Cork, Ireland; ²Fraunhofer Institute for Energy Economics and Energy System Technology, Germany; ³Ocean Renewable Power Company, Ireland
WEDNESDAY: SESSIONS

9:05 am–9:30 am
Aggregate Model of Single Phase Induction Motors
Bikrant Poudel1, Rochak Shiwakoti2, Ebrahim Amirî1, Parviz Rastgoufard1, Thomas E. Field1, Jayanth Ramamurthy2
1University of New Orleans, USA; 2Entergy Corp., USA

9:30 am–9:55 am
System Loss Measurement of a Novel Outer Rotor Flywheel Energy Storage System
Maximilian Schneider, Stephan Rinderknecht
Technische Universität Darmstadt, Germany

8:40 am–9:55 am
ROOM: SIERRA B

Machine Manufacturing
Sessions Chairs: Ronghai Qu; Alireza Fatemi
8:40 am–9:05 am
Hot Crimping through Innovative Inductive Heating in the Production of Electric Motors
Alexander Kuehl, Maximilian Zitzelsberger, Johannes Seefried, Michael Masuch, Tim Miller, Joerg Franke
Friedrich-Alexander-University Erlangen-Nuremberg, Germany

9:05 am–9:30 am
Design and Construction of an IPM Motor for Automatic Tapping Machine Tool Applications
Cheng-Tsung Liu1, Chang-Chou Hwang2
1National Sun Yat-Sen University, Taiwan; 2Feng Chia University, Taiwan

8:40 am–9:55 am
ROOM: SIERRA A

Electric Machines Drives for Transportsations Applications
Sessions Chairs: Shanelle Foster; Herbert Hess
8:40 am–9:05 am
Evaluation of Efficiency-Shifting Permanent Magnet Motor in Electric Vehicle
Hoyun Won, Yang-Ki Hong, Minyeong Choi, Woncheol Lee, Shuhui Li, Hwan-Sik Yoon
The University of Alabama, USA

9:05 am–9:30 am
A Dual-Channel Enhanced Power Generation Architecture with Back-to-Back Converter for MEA Application
Xiaoyu Lang, Tao Yang, Hossein Balaghi Enalou, Chen Li, Serhiy Bozhko, Patrick Wheeler
University of Nottingham, UK

9:30 am–9:55 am
A New Three-Phase Hybride Excitation Flux-Switching Machine for EV/HEV Applications
Ruiwu Cao, Xue Zhang, Xinyi Yuan
Nanjing University of Aeronautics and Astronautics, China

8:40 am–9:55 am
ROOM: SANTA FE

Machine Modeling and Manufacturing
Sessions Chairs: Chushan Li; Pinjia Zhang
8:40 am–9:05 am
Semi-Analytical Calculation of Field Distribution in Yoke/Tooth Transition in Electrical Machines
Alexander Rehfeldt1, Torben Fricke1, Dirk Emmrich1, Bernd Ponick1
1Leibniz University Hannover, Germany; 2Voith Hydro Holding GmbH & Co. KG, Germany

9:05 am–9:30 am
Magnetic Field Prediction in Surface-mounted PM Machines with Parallel Slot based on a Nonlinear Subdomain and Magnetic Circuit Hybrid Model
Hao Yin, Lijian Wu, Yuting Zheng, Youtong Fang
Zhejiang University, China
9:30 am–9:55 am
Analytical-Based Optimization of SMPM Machines for Sizing Validation Purposes
Silvio Vaschetto\textsuperscript{1}, Gerd Bramerdorfer\textsuperscript{2}, Andrea Cavagnino\textsuperscript{1}, Alberto Tenconi\textsuperscript{1}
\textsuperscript{1}Politecnico di Torino, Italy; \textsuperscript{2}Johannes Kepler University Linz, Austria

3:00 pm–4:40 pm
ROOM: PLAZA A

TTTR3: Analysis of Electric Machines for Transportation Applications
Sessions Chairs: Nuh Erdogan; Ashfanoor Kabir

3:00 pm–3:25 pm
Impact of Ultra-Conducting Winding on the Power Density and Performance of Non-Heavy Rare Earth Traction Motors
Tsarafidy Raminosoa, Tolga Aytug
Oak Ridge National Laboratory, USA

3:25 pm–3:50 pm
AC Winding Losses in Automotive Traction E-Machines: A New Hybrid Calculation Method
Giuseppe Volpe\textsuperscript{1,2}, Mircea Popescu\textsuperscript{1}, Fabrizio Marignetti\textsuperscript{3}, James Goss\textsuperscript{2}
\textsuperscript{1}Motor Design Ltd., UK; \textsuperscript{2}University of Cassino, UK

3:50 pm–4:15 pm
Principle of a Novel Dual-mode Reluctance Motor for Electric Vehicle Applications
Kyohei Kyota, Kosuke Ichiyangi, Kenji Amei, Takahisa Ohji
University of Toyama, Japan

3:00 pm–4:15 pm
ROOM: PLAZA B

Thermal, Material and Efficiency Issues in Electrical Machines
Sessions Chairs: Sabrina Ayat; Shafigh Nategh

3:00 pm–3:25 pm
A Hybrid Thermal Modeling Method for Traction Motors Used in Duty-cycles
Claudio Scena\textsuperscript{1}, Shafigh Nategh\textsuperscript{2}, Aldo Boglietti\textsuperscript{1}, Luca Boscaglia\textsuperscript{1}, Daniel Ericsson\textsuperscript{3}
\textsuperscript{1}Politecnico di Torino, Italy; \textsuperscript{2}ABB AB, Sweden; \textsuperscript{3}COMSOL AB, Sweden

3:25 pm–3:50 pm
Salvatore La Rocca\textsuperscript{1}, Stephen J. Pickering\textsuperscript{1}, Carol N. Eastwick\textsuperscript{1}, Chris Gerada\textsuperscript{1}, Kristian Rönnberg\textsuperscript{1}
\textsuperscript{1}University of Nottingham, UK; \textsuperscript{2}ABB AB Corporate Research, Sweden

3:50 pm–4:15 pm
Design and Thermal Analysis of a Rotating Transformer
Jonathan Godbehere\textsuperscript{1}, Andrew Hopkins\textsuperscript{2}, Xibo Yuan\textsuperscript{1}, Andrew Bloor\textsuperscript{2}, Phil Mellor\textsuperscript{2}
\textsuperscript{1}Motor Design Limited, UK; \textsuperscript{2}University of Bristol, UK

4:15 pm–4:40 pm
Design of Liquid Cooled IPM Motor for High Torque Density Applications
Dylan Broomfield, Russ Marvin
LC Drives, USA

3:00 pm–4:40 pm
ROOM: PLAZA C

PM Machines
Sessions Chairs: Mark Thiele; Glynn Attkinson

3:00 pm–3:25 pm
A Novel Drive Train Concept for Personalized Upper Body Exoskeletons with a Multiphase Axial Flux Machine
Marcel Waldhoff, Andreas Echle, Nejila Parspour
University of Stuttgart, Germany
WEDNESDAY: SESSIONS

3:25 pm–3:50 pm
Effects of Manufacturing Imperfections and Design Parameters on Radial Magnetic Forces in the BLDC Claw-Pole Motor
Stefan Leitner, Hannes Gruebler, Annette Muetze
Graz University of Technology, Austria

3:50 pm–4:15 pm
Comparative Study Between Doubly Salient PM Machine with New Stator/Rotor-Pole Number Combination and Biased Flux PM Machine
Lijian Wu, Guangqiang Ming, Liu Zhang, Youtong Fang
Zhejiang University, China

3:00 pm–4:40 pm
ROOM: SIERRA A

Predictive Control of Electrical Drives
Sessions Chairs: Nasir Mohammad Uddin; Radu Bojoi

3:00 pm–3:25 pm
Hierarchical Model Predictive Speed and Current Control of an Induction Machine Drive with Moving-Horizon Load Torque Estimator
Oliver Wallscheid, Etienne Florian Bouna Ngoumtsa, Joachim Böcker
Paderborn University, Germany

3:25 pm–3:50 pm
A Novel Formulation of Continuous Control Set MPC for Induction Motor Drives
Andrea Favato, Paolo Gherardo Carlet, Francesco Toso, Silverio Bolognani
University of Padova, Italy

3:50 pm–4:15 pm
Finite Control Set Model Predictive Control for the Dual Fed Common dc-link Open-End Winding PMSM Drive
Luca Rovere, Andrea Formentini, Pericle Zanchetta
University of Nottingham, UK

4:15 pm–4:40 pm
Continuous-Control-Set Model Predictive Control With Integrated Modulator in Permanent Magnet Synchronous Motor Applications
Sören Hanke, Oliver Wallscheid, Joachim Böcker
Paderborn University, Germany

3:00 pm–4:40 pm
ROOM: SIERRA B

Machine Review Papers
Sessions Chairs: Ronghai Qu; Pinjia Zhang

3:00 pm–3:25 pm
Design Guidelines for Synchronous Machine Topologies with High Torque and Wide Field Weakening Demands
Sridhar Balasubramanian, Christian Heister, Markus Henke
Technische Universität Braunschweig, Germany

3:25 pm–3:50 pm
Towards Fully Additively-Manufactured Permanent Magnet Synchronous Machines: Opportunities and Challenges
Fan Wu, Ayman M. El-Refaie
Marquette University, USA

3:50 pm–4:15 pm
Introducing Physics of Failure Considerations in the Electrical Machines Design
Vincenzo Madonna¹, Paolo Giangrande², Michael Galea³
¹University of Nottingham, UK

4:15 pm–4:40 pm
Dual-Stator Line-Start Vernier Permanent Magnent Synchronous Machine
Mengxuan Lin, Dawei Li, Xiang Ren, Kangfu Xie, Ronghai Qu
Huazhong University of Science and Technology, China
3:00 pm–4:40 pm
ROOM: SANTA FE

Machine Modeling
Sessions Chairs: Alireza Fatemi; Hiu Yang

3:00 pm–3:25 pm
Braking Torque Compensation Strategy and Thermal Behavior of a Dual Three-Phase Winding PMSM During Short-Circuit Fault
P. Giangrande1, V. Madonna1, S. Nuzzo1, C. Gerada1, M. Galea2
1University of Nottingham, UK

3:25 pm–3:50 pm
Application of a Hybrid Modeling Approach for Eddy Current Estimation in Hairpin Windings
David Philipp Morisco1,2, Ioan Liviu Iepure1, Andreas Moeckel1
1Robert Bosch GmbH, Germany; 2Technical University of Ilmenau, Germany

3:50 pm–4:15 pm
A Novel Variable Flux Dual-Layer Hybrid Magnet Memory Machine with Bypass Airspace Barriers
Hui Yang1, Hao Zheng1, Heyun Lin1, Z.Q. Zhu2, Shukang Lyu1
1Southeast University, China; 2The University of Sheffield, UK

4:15 pm–4:40 pm
A Comparative Study of Methods for Calculating AC Copper Loss in Permanent Magnet Machines
Narges Tarani, Vandana Rallabandi, Dan M. Ionel, Greg Heins, Dean Patterson
1University of Kentucky, USA; 2Regal Beloit Corp., Australia

POSTER SESSIONS

Poster Session #2 | 10:30 am–12:00 pm
Rotating Electric Machines
Sessions Chairs: Seshadri S. Kumar; Chushan Li

Deep Residual Convolutional and Recurrent Neural Networks for Temperature Estimation in Permanent Magnet Synchronous Motors
Wilhelm Kirchgässner, Oliver Wallscheid, Joachim Böcker
Paderborn University, Germany

The Development of a New Type of Repulsion-Induction Motor
Aurelian Crăciunescu
University Politehnica of Bucharest, Romania

An Approach to Design of Energy Efficient Single Phase Induction Motor for Ceiling Fans
Utkarsh Sharma, Bhim Singh
Indian Institute of Technology Delhi, India

Hybrid Magnet – Field Winding Solutions for Exciters of Synchronous Generators
Giovanni Decuzzi1, Stefano Nuzzo2, Paolo Bolognesi2, Paolo Giangrande1, Michael Galea2
1University of Nottingham, UK; 2University of Pisa, Italy

Experimental Comparison of Synchronous Reluctance Motors with and without Ferrite Magnet Assistance
Sascha Neusü, Andreas Binder
Technische Universität Darmstadt, Germany

Experimental Verification of a Motor with Two Axially-Arranged Rotors
Hironori Suzuki, Katsuhiko Hirata, Noboru Niguchi, Akira Kohara
Osaka University, Japan

Experimental Study of Torque Ripple and its Effect on the Flux Weakening Range of Synchronous Reluctance Machine
Rajendra Thike, Pragases Pillay
Concordia University, Canada

Online Characterization of a Synchronous Generator Using an Unscented Kalman Filter
Andrew G. Miles1, Brian K. Johnson1, Normann Fischer2
1University of Idaho, USA; 2Schweitzer Engineering Laboratories, USA

Stator/Rotor Pole Combinations of Variable Flux Reluctance Machines with 2nd Harmonic Current Injection Method
L.R. Huang1, Z.Q. Zhu1, J.H. Feng2, S.Y. Guo2, J.X. Shi2
1The University of Sheffield, UK; 2CRRC Zhuzhou Institute Co. Ltd., China

Analytical Evaluation of High-Efficiency Induction Motor Losses
Lassi Järvenranta1, Pia Lindh1, Hannu Kärkkäinen2, Markku Niemelä2, Juha Pyrhönen2, Wenping Cao3
1Aston University, UK; 2Lappeenranta-Lahti University of Technology, Finland
WEDNESDAY: SESSIONS

A comparison of conventional and segmental rotor 12/10 switched reluctance motors
Xu Deng, Barrie Mecrow
Newcastle University, UK

Analysis of the Rotor Currents Influence on a Line-Start Vernier Motor
Vincent Fedida, Mengxuan Lin, Dawei Li, Ronghai Qu
Huazhong University of Science and Technology, China

Design and Analysis of Modular Axial Flux Switched Reluctance Motor
Rochak Shiwakoti1, Bikrant Poudel1, Ebrahim Amiri1, Mohammad Divandari2, Aliakbar Damaki3
1University of New Orleans, USA; 2Azad University, Iran; 3Yazd University, Iran

A Novel Dual Stator Line-Start Permanent Magnet Synchronous Machine
Yu Zhao, Dawei Li, Mengxuan Lin, Ronghai Qu
Huazhong University of Science and Technology, China

FEM Analysis of the Inter-Bar Currents in Induction Motors Aimed at Estimating Contact Resistance
Zbigniew Gmyrek1, Andrea Cavagnino2, Silvio Vaschetto2
1Lodz University of Technology, Poland; 2Politecnico di Torino, Italy

Control-based Performance Improvements of a Single-Phase Induction Machine with a Large Air Gap and a Copper-Coated Solid Rotor
Christiane Mellak1, Hannes Gruebler1, Heinrich T. Eickhoff4, Josef Deuringer5, Klaus Krischan1, Annette Muetze1
1Graz University of Technology, Austria; 2Siemens Healthcare GmbH, Germany

Study on Design Method for Increasing Power Density of Induction Motors for Electric Railway Vehicle Traction
Ryotaro Ikeda1, Sadali Yusya2, Keiichiro Kondo2
1Chiba University, Japan; 2Waseda University, Japan

Advanced Uncertainty Calculation Method for Converter-Fed Motor Loss Determining
Hannu Kärkkäinen1, Lassi Aarniovuori2, Markku Niemelä1, Juha Pyrhönen1
1Lappeenranta-Lahti University of Technology, Finland; 2Aston University, UK

Magneticalley Geared Direct Online Machine
Bahareh Anvari, Ashfanoor Kabir, Rajib Mikail, Colin Tschida, Chenjie Lin
ABB Inc., USA

Experimental Validation of a High-Power Slotless Stator
Aaron D. Anderson, Yuyao Wang, Yangxue Yu, Kiruba S. Haran
University of Illinois Urbana-Champaign, USA

Quantifying Parameter Variability on a Population of Aerospace Synchronous Generators
Kevin J. Yost1, Brett A. Robbins2, William Perdikakis3, Chase Kitzmiller4, Kaitlyn Jones1, Raymond R. Hill6
1Air Force Research Laboratory, USA; 2PC Krause & Associates, USA; 3UES, Inc., USA; 4The Perduco Group, USA; 5Air Force Institute of Technology, USA

A Novel Stator Spoke-Type Hybrid Magnet Memory Machine
Hui Yang1, Heyun Lin2, Z.Q. Zhu2, Shuangxia Niu2, Shukang Lyu1, Hao Zheng3
1Southeast University, China; 2The University of Sheffield, UK; 3The Hong Kong Polytechnic University, China

Comparing Calculation Methods for Damper Bars in Synchronous Electric Machines
William Perdikakis, Hongyu Wang, Bailey Hall, Longya Xu
The Ohio State University, USA

Control of Electrical Drives
Sessions Chairs: Fan Wu; Keiichiro Kondo

Coordinated Power Sharing for Enhanced Utilization of Mixed Energy Storage Media in Dual-Inverter Electric Vehicles
Ruoyun Shi, Sepehr Semsar, Peter W. Lehn
University of Toronto, Canada

Jordi Van Damme, Lynn Verkroost, Hendrik Vansompel, Frederik De Belie, Peter Sergeant
Ghent University, Belgium

Analysis of External Rotor Electric Drives for an All-Automatic Airborne Wind Energy System
Stefan Urbanek1, Daniel Heide2, Bakr Bagaber2, Martin Lohss2, Bernd Specht3, Xaver Paulig1, Axel Mertens1, Bernd Ponick2
1Leibniz University Hannover, Germany; 2SkySails Power GmbH, Germany
Control of Induction Motor Drive based on ADRC and Inertia Estimation
Hao Wu, Jin Huang
Zhejiang University, China

Filterless Mitigation of Machine Terminal Reflected Wave Voltage Stress
Robert W. Maier, Mark-M. Bakran
University of Bayreuth, Germany

Quasi-Two-Level Converter Operation Strategy for Overvoltage Mitigation in Long Cable Applications
Federico Bertoldi\textsuperscript{1}, Mehanathan Pathmanathan\textsuperscript{2}, R.S. Kanchani\textsuperscript{3}
\textsuperscript{1}ABB AB, Sweden; \textsuperscript{2}University of Toronto, Canada

Safety Operation Area of Zero-Crossing Detection Based Sensorless High Speed BLDC Motor Drives
Lei Yang\textsuperscript{1}, Z.Q. Zhu\textsuperscript{1}, Hong Bin\textsuperscript{2}, Zhuya Zhang\textsuperscript{2}
\textsuperscript{1}The University of Sheffield, UK; \textsuperscript{2}Midea Group Corporate Research Center, China

Experimental Assessment of Motor Core Loss, Inverter Loss and Ringing Phenomenon under SiC-MOSFET Inverter Excitation
Nauyngia Minh Thao\textsuperscript{1}, Shuangshuang Zhong\textsuperscript{1}, Keisuke Fujisaki\textsuperscript{1}, Fujiyuki Iwamoto\textsuperscript{2}, Tomonori Kimura\textsuperscript{2}, Takahiro Yamada\textsuperscript{2}
\textsuperscript{1}Toyota Technological Institute, Japan; \textsuperscript{2}DENSO Corp., Japan

A Power Hardware-in-the-loop Emulation of a Faulted Inverter
Matthews Boby, Pragasen Pillay
Concordia University, Canada

Pump-Back Validation of A Medium Voltage High-Frequency “SiC+Si” Hybrid Three-Level ANPC Inverter for Hybrid-Electric Propulsion Application
Di Pan\textsuperscript{1}, Di Zhang\textsuperscript{1}, Jianguiao He\textsuperscript{2}, Chris Immer\textsuperscript{1}, Mark Dame\textsuperscript{1}
\textsuperscript{1}GE Global Research, USA; \textsuperscript{2}University of Kentucky, USA

Stability Analysis and Control of a Rotary Transformer-Based Field Excitation System for Synchronous Motor
Josiah Haruna\textsuperscript{1}, Tsarafidy Raminosoa\textsuperscript{1}, Olorunfemi Ojo\textsuperscript{1}
\textsuperscript{1}Tennessee Tech University, USA; \textsuperscript{2}Oak Ridge National Laboratory, USA

Torque Ripple Reduction in High Power BLDC Motors Utilizing an Auxiliary DC to DC Converter
Suman Kumar Neogi, Kishore Chatterjee
Indian Institute of Technology, Bombay, India

Current Source Inverter Drive System for Switched Reluctance Motors
Mohammadreza Dibaji\textsuperscript{1}, Aliakbar Damaki Aliabad\textsuperscript{1}, Ebrahim Amir\textsuperscript{2}, Mohammad Divandari\textsuperscript{1}
\textsuperscript{1}Yazd University, Iran; \textsuperscript{2}University of New Orleans, USA

An Improved Two-Vector Model Predictive Torque Control based on RMS Duty Ratio Optimization for PMSM
Chenwei Ma\textsuperscript{1,2}, Xuliang Yao\textsuperscript{1}, Huayu Li\textsuperscript{1}, Frederik De Belie\textsuperscript{1}
\textsuperscript{1}Ghent University, Belgium; \textsuperscript{2}Harbin Engineering University, China

High-Precision Adaptive Backstepping Optimal Control Using RBFN for PMSM–Driven Linear Motion Stage
Fayez F.M. El-Sousy\textsuperscript{3}, Mahmoud Amir\textsuperscript{4}, Osama A. Mohammed\textsuperscript{2}
\textsuperscript{1}Prince Sattam bin Abdulaziz University, Saudi Arabia; \textsuperscript{2}Manhattan College, USA; \textsuperscript{3}Florida International University, USA

Limitations of the PI Control with Respect to Parameter Variation in PMSM Motor Drive Systems
Anant Kumar Singh, Ramakrishnan Raja, Tomy Sebastian, Awab Ali
Hallia Mechatronics, USA

Active DC-Power Filters for Switched Reluctance Drives Based on Dual-Active Bridge Converters
Annegret Klein-Hessling, Kevin Felsing, Rik W. De Doncker
RWTH Aachen University, Germany

Sliding Mode Control for Permanent Magnet Synchronous Motors using Conditional Integrators
Sridhar Seshagiri\textsuperscript{1}, Nitya Krishnan\textsuperscript{2}, Jordana Bratt\textsuperscript{6}
\textsuperscript{1}San Diego State University, USA; \textsuperscript{2}Viasat, Inc., USA

Robust Sensorless Scalar Control of Induction Motor Drives with Torque Capability Enhancement at Low Speeds
Zhe Zhang\textsuperscript{1}, Ali Bazzi\textsuperscript{2}
\textsuperscript{1}University of Connecticut, USA

Differential Evolution Based Stator Flux Linkage Estimation Considering Saturation, Inverter Non-linearity and Saliency in PMSM
Animesh Kundu, Aiswarya Balamurali, Guodong Feng, Narayan C. Kar
University of Windsor, Canada
DISCUSSION ON CONTROL METHODS WITH FINITE-CONTROL-SET CONCEPT FOR PMSM DRIVES

Zhenkun Zhang1, Zhenbin Zhang1, Cristian Garcia2, José Rodriguez2, Weiqing Huang3, Ralph Kennel3
1Shandong University, China; 2Universidad Andres Bello, Chile; 3Technische Universität of Munich, Germany

ROTOR TRANSFORMER FOR CONTACTLESS EXCITATION OF SYNCHRONOUS MACHINES FED THROUGH NEUTRAL CONDUCTOR

Stefan Uedema, Carsten Fräger
University of Applied Science and Arts, Germany

POSITION SENSING INDUCED PARASITIC TORQUES IN PERMANENT MAGNET SYNCHRONOUS MOTOR DRIVES

Prerit Pramod, Krishna Namburi, Rakesh Mitra, Aparna Saha
Nexteer Automotive Corp., USA

SENSORLESS CONTROL OF SYNCHRONOUS RELUCTANCE MOTOR DRIVES BASED ON THE TLS EXIN NEURON

Yong-Chao Liu1, Salah Lhaghouache1, Abdoul N'Diaye2, Siwan Narayan1, Giansalvo Cirrincione3, Maurizio Cirrincione1
1Université Bourgogne Franche-Comté, France; 2University of the South Pacific, Fiji; 3University of Picardie “Jules Verne”, France

HIGH-PERFORMANCE LINEAR MACHINES AND DRIVES

Sessions Chair: Renato Galluzzi

MOVER POSITION DETECTION FOR PMSLM BASED ON SINUSOIDAL FRINGE PATTERN AND FOURIER PHASE ANALYSIS

Jing Zhao, Jiwen Zhao, Fei Dong, Juncai Song, Fang Xie
Anhui University, China

NEW DOUBLE-SIDED WOUND FIELD FLUX-SWITCHING LINEAR MOTOR WITH NON-OVERLAPPING WINDING

Ruiwu Cao, Enhao Su
Nanjing University of Aeronautics and Astronautics, China

INVESTIGATION OF PREDICTION MODELS OF VERTICAL AND TRANSVERSAL FORCES IN LINEAR INDUCTION MOTOR WITH DATA-BASED SYSTEM IDENTIFICATION ALGORITHMS

Gang Lv1, Dihui Zeng1, Tong Zhou2, Michele Degano2
1Beijing Jiaotong University, China; 2University of Nottingham, UK

DEMAGNETIZATION MODELING RESEARCH FOR PERMANENT MAGNET IN PMSLM USING EXTREME LEARNING MACHINE

Juncai Song, Jiwen Zhao, Fei Dong, Jing Zhao, Liang Xu, Lijun Wang, Fang Xie
Anhui University, China

CORE LOSS MINIMIZATION OF THE LINEAR GENERATOR BY USING HIGH GRADED MAGNETIC MATERIALS FOR HARVESTING OCEANIC WAVE ENERGY

Omar Farrok1, Mahbubur Rahman Kiran1, Md Rabiu Islam2, Wei Xu3, Jianguo Zhu4
1Ahsanullah University of Science and Technology, Bangladesh; 2University of Wollongong, Australia; 3Huazhong University of Science and Technology, China; 4The University of Sydney, Australia

A COMPLETE EQUIVALENT CIRCUIT MODEL FOR LINEAR INDUCTION MOTOR CONSIDERING THRUST, VERTICAL AND TRANSVERSAL FORCES

Dihui Zeng1, Gang Lv1, Tong Zhou2, Michele Degano2
1Beijing Jiaotong University, China; 2University of Nottingham, UK

LINEAR OSCILLATORY PMSM DRIVES: A REVISIT IN 2019

I. Boldea1, L.N. Tutelea1, A.A. Popa1, Wei Xu2
1Politehnica University Timisoara, Romania; 2Huazhong University of Science and Technology, China

MULTIPHASE MACHINES AND DRIVES

Sessions Chair: Yoshihiro Miyama

CIRCULATING HARMONIC CURRENTS PREDICTION FOR VSI FEEDED THREE-PHASE IPMSM

Donglin Ye, Jian Li, Ronghai Qu
Huazhong University of Science and Technology, China

DESIGN AND OPTIMIZATION OF A SYNCHRONOUS RELUCTANCE MACHINE FOR FAULT-TOLERANT APPLICATIONS

Cristian Babetto1, Nicola Bianchi1, Ambra Torreggiani2, Claudio Bianchini1, Matteo Davoli1, Alberto Bellini1
1University of Padova, Italy; 2University of Modena and Reggio Emilia, Italy; 3Raw Power S.r.l., Italy; 4University of Bologna, Italy

NEW DIRECT TORQUE AND FLUX CONTROL WITH IMPROVED TORQUE PER AMPERE FOR SWITCHED RELUCTANCE MOTOR

Krishna Reddy Pittam1, Deepak Ronanki2, Parthiban Perumal3, Sheldon S. Williamson3
1National Institute of Technology Karnataka, India; 2University of Ontario Institute of Technology, Canada

NONLINEAR BACKSTEPPING WITH TIME DELAY ESTIMATION FOR SIX-PHASE INDUCTION MACHINE

Yassine Kali1, Jorge Rodas2, Maarouf Saad2, Jesus Doval-Gandoy1, Raul Gregor2
1École de Technologie Supérieure, Canada; 2Universidad Nacional de Asunción, Paraguay; 3Universidad de Vigo, Spain
Information Technologies for Distributed Machine Drives: An Overview
Filippo Savi1, Giampaolo Buticchi2, Chris Gerada1, Pat Wheeler1, Davide Barater2
1University of Nottingham Ningbo, China; 2University of Modena and Reggio Emilia, Italy

Fast Evaluation of High Frequency Electromagnetic Force and Vibration for Electrical Machines Based on Field Reconstruction Technique
Yunsong Xu, Haiyang Fang, Dawei Li, Ronghai Qu, JiaXiong Guo
Huazhong University of Science and Technology, China

An Equivalent Winding Factor Larger than 1 by Using Flux Barriers in the Stator
Johannes Walter Gerold1, Dieter Gerling2
1FEAM GmbH, Germany; 2Bundeswehr University Munich, Germany

Comparison of AC Motors to an Ideal Machine Part II: Non-Sinusoidal AC Machines
Thomas A. Lipo, Wenbo Liu, Zhentao Du
University of Wisconsin, USA

A Method to Suppress Vibration Due to Fabrication Tolerance by using Triple Three-Phase Winding Motor
Kan Yang1, Kan Akatsu1, Yoshihiro Miyama2, Kodai Okazaki2
1Shibaura Institute of Technology, Japan; 2Mitsubishi Electric Corp., Japan

Efficiency Improvement of In-Wheel Magnetic-Geared Motor and Feasibility Study for Walking Support Machines
Koki Ito, Takahisa Kadomatsu, Kenji Nakamura
Tohoku University, Japan

A Trade Study on Motor Types for Large HVAC Systems with Integrated Motor-Compressors
Samith Sirimanna1, Byung Hoon Min1, Xiaolong Zhang1, Yangxue Yu1, Xuan Yi1, Kiruba Haran1, Ivan Jdrlic2, Matt Heisey2, Ajit Kane2, Jeb Schreiber2
1University of Illinois Urbana-Champaign, USA; 2Johnson Controls International PLC, USA

A Comparative Study between System-Level PMSM Models with Either Current or Flux-Linkage State Variables Used for Vibro-Acoustic Computation
Sebastian Ciceo1,2,3, Fabien Chauvicourt1, Johan Gyseleinck2, Claudia Martis3
1Siemens Industry Software, Belgium; 2Université Libre de Bruxelles, Belgium; 3Technical University of Cluj-Napoca, Romania

On the Design of Partial Discharge-Free Low Voltage Electrical Machines
Vincenzo Madonna1, Paolo Giangrande1, Weiduo Zhao2, He Zhang2, Chris Gerada3, Michael Galea3
1University of Nottingham, UK; 2University of Nottingham Ningbo, China

A Trade Study on Motor Types for Large HVAC Systems with Integrated Motor-Compressors
Samith Sirimanna1, Byung Hoon Min1, Xiaolong Zhang1, Yangxue Yu1, Xuan Yi1, Kiruba Haran1, Ivan Jdrlic2, Matt Heisey2, Ajit Kane2, Jeb Schreiber2
1University of Illinois Urbana-Champaign, USA; 2Johnson Controls International PLC, USA

A Comparison of AC Motors to an Ideal Machine Part II: Non-Sinusoidal AC Machines
Thomas A. Lipo, Wenbo Liu, Zhentao Du
University of Wisconsin, USA

A Method to Suppress Vibration Due to Fabrication Tolerance by using Triple Three-Phase Winding Motor
Kan Yang1, Kan Akatsu1, Yoshihiro Miyama2, Kodai Okazaki2
1Shibaura Institute of Technology, Japan; 2Mitsubishi Electric Corp., Japan

Efficiency Improvement of In-Wheel Magnetic-Geared Motor and Feasibility Study for Walking Support Machines
Koki Ito, Takahisa Kadomatsu, Kenji Nakamura
Tohoku University, Japan

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A Magnetic Equivalent Circuit for Excitation System Design
Adam Larson1, Steven D. Pekarek1
1Kohler Power, USA; 2Purdue University, USA

3D-Printed Rapid Prototype Rigs for Surface Mount PM Rotor Controlled Segment Magnetisation and Assembly
Juan I. Melecio1, A. Mohammed1, Nigel Schofield2, S. Djurović1
1The University of Manchester, UK; 2University of Huddersfield, UK

A Review of Electrical Machine Optimization Methods with Emphasis on Computational Time
Qingqing Ma1, Hao Chen1, Ayman EL-Refaie1, Yue Sun1
1Marquette University, USA; 2Beijing Institute of Technology, China

Poster Session #3 | 1:00 pm–3:30 pm

Rotating Electric Machines

Sessions Chairs: Pinjia Zhang; Alireza Fatemi

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Schwarz-Christoffel-Based Open-Circuit Clamping Plate Field Calculation in Hydro Generators
Torben Fricke1, Babette Schwarz2, Bernd Ponick1
1Leibniz University Hannover, Germany; 2Voith Hydro Holding GmbH & Co. KG, Germany

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Fast Evaluation of High Frequency Electromagnetic Force and Vibration for Electrical Machines Based on Field Reconstruction Technique
Yunsong Xu, Haiyang Fang, Dawei Li, Ronghai Qu, JiaXiong Guo
Huazhong University of Science and Technology, China

An Equivalent Winding Factor Larger than 1 by Using Flux Barriers in the Stator
Johannes Walter Gerold1, Dieter Gerling2
1FEAM GmbH, Germany; 2Bundeswehr University Munich, Germany

A Method to Suppress Vibration Due to Fabrication Tolerance by using Triple Three-Phase Winding Motor
Kan Yang1, Kan Akatsu1, Yoshihiro Miyama2, Kodai Okazaki2
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Analysis of Inherent Unbalanced Currents in Three-Phase Multi-Branch Brushless Exciter
Wei Du, Yuguang Sun, Lin Gui
Tsinghua University, China

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Sebastian Ciceo1,2,3, Fabien Chauvicourt1, Johan Gyseleinck2, Claudia Martis3
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Design of a Hybrid Magnets Variable Flux Memory Machine Based on Hysteresis Model
Hai Xu, Jian Li, Junhua Chen, Meng Ge
Huazhong University of Science and Technology, China

A Review of Electrical Machine Optimization Methods with Emphasis on Computational Time
Qingqing Ma1, Hao Chen1, Ayman EL-Refaie1, Yue Sun1
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WEDNESDAY: SESSIONS

Optimal Design of a Fully Superconducting Machine for 10-MW Offshore Wind Turbines
Thanatheepan Balachandran, Dongsu Lee, Kiruba S. Haran
University of Illinois Urbana-Champaign, USA

Modeling and Analysis of Novel Star-Delta Winding Configuration with Odd Slot Numbers for Reduced Space Harmonics Using Winding Function
 Shruthi Mukundan, Himavarsha Dhulipati, Guodong Feng, Jimi Tjong, Narayan C. Kar
University of Windsor, Canada

Voltage Stress Modeling and Measurement for Random-wound Windings Driven by Inverters
Yanyan Xie1, Julia Zhang1, Franco Leonardii, Alfredo R. Munozii, Micheal W. Degnerii, Feng Liang1
1The Ohio State University, USA; 2Ford Motor Company, USA

Special Machines
Sessions Chairs: Dean Patterson; Nick Baker

Optimization of Transverse Flux Permanent Magnet Machine with Double-hoop Stator
Zhou Jia, Lin Wu, Weifeng Chen, Li Yu, Yongjuan Cao, Hongyun Jia
Nanjing University of Information Science and Technology, China

Mathematical Model for a Novel Electromechanical Actuator Based on Lagrange-Maxwell Equation
Jinhua Du1, Yun Long1, Shangbin Yuan1, Jiangbiao He2, Kun Yang3, Shixiao Li1
1Xi’an Jiaotong University, China; 2University of Kentucky, USA

Unbalance Vibration Compensation of Magnetic Bearing Systems Based on Beetle Antennae Search Algorithm
Hongbo Sun, Dong Jiang, Zaidong Hu, Tian Li, Junquan Lai
Huazhong University of Science and Technology, China

Accelerating Virtual Hotspots Analysis in Static Electromagnetic Devices
John Wanjiku
Mentor Graphics, A Siemens Business, Canada

Assessing the Effect of Geometric Error on the Performance of Magnetic Gears
Alexandros Leontaris, Aydin Nassehi, Jason Yon
University of Bristol, UK

Magnetic Equivalent Circuit Modeling of Partitioned Stator Doubly Salient Permanent Magnet Machines
Warat Sriwannarat1, Nuwantha Fernando2, Apirat Sirirattirawat1, Pirat Khunkiti1
1Khon Kaen University, Thailand; 2RMIT University, Australia

A General Framework for the Analysis and Design of a Wireless Resonant Motor
Besong John Ebot, Yasutaka Fujimoto
Yokohama National University, Japan

Decoupled Model for Asymmetrical Dual Three Phase Permanent Magnet Synchronous Machine
Yuzheng Chen, Linhui Fan, M. Raza Khowja, Serhiy Bozhko, Tao Yang
University of Nottingham, UK

Performance of a Halbach Cycloidal Magnetic Gear with Respect to Torque Density and Gear Ratio
Hailin Huang1, Jonathan Bird2, Ronghai Qu1
1Huazhong University of Science and Technology, China; 2Portland State University, USA

Nonlinear Modeling of a Magnetic Levitation System
Xing-Dong Fu, Su-Dan Huang, Guang-Zhong Cao, Chao Wu, Wen-Bo Li, Xiao-Sheng Yang
Shenzhen University, China

Parametric analysis and design of magnetic lead screw
Xiao Liu, Yuxing Liu, Xiongsong Li
Hunan University, China

An Improved Radial Force Model of Sharing Suspension Windings Bearingless Switched Reluctance Motor
Yi Hao, Xilian Wang, Di Cheng
Beijing Jiaotong University, China

High-Frequency Analysis and Measurement Techniques with Mixed-Mode Conversion of Induction Motors for Shaft-Voltage Prediction
Manje Yea1, Younggon Ryu2, Jieunok Kim2, Ki Jin Han3
1Ulsan National Institute of Science and Technology, Korea (South); 2LG Electronics, Korea (South); 3Dongguk University, Korea (South)

A Study on Electromagnetic-Spring Actuator for Low Cost Miniature Actuators
Sewoong Kim, Changseop Lee, Hyunyoung Choi
Agency for Defense Development, Korea (South)
A Novel DC Biased Current Dual PM Vernier Machine
Shaofeng Jia1, Kuankuan Yan1, Deliang Liang1, Ronghai Qu1, Jinjun Liu2, Jiangbiao He2
1Xi’an Jiaotong University, China; 2Huazhong University of Science and Technology, China; 3University of Kentucky, USA

Thermal, Material, and Efficiency Issues in Electrical Machines
Sessions Chairs: Guang-Jin Li; Michael Galea

Thermal Network Calibration Using Short-Transient and Steady-State Thermal Tests
Eric Armando1, Aldo Boglietti2, Enrico Carpaneto1, Devi Geetha Nair2
1Politecnico di Torino, Italy; 2Aalto University, Finland

Electromagnetic Properties of Soft Magnetic Composites and Electrical Steels at High Frequencies Considering Material Manufacturing Techniques
Daniel Gumbleton-Wood1, Glynn J. Atkinson1, Lars Sjöberg2
1Newcastle University, UK; 2Höganäs AB, Sweden

Scaling of Permanent Magnet Machines with Thermal Effects
Nicklas Makowski, Brian Helenbrook
Clarkson University, USA

SMC Materials in Electrical Machine Prototypes
Emir Pošković, Luca Ferraris, Fausto Franchini, Andrea Cavagnino, Marco Actis Grande
Politecnico di Torino, Italy

Equivalent Thermal Conductivity Prediction of Form-Wound Windings with Litz Wire
Xuan Yi, Xiaojian Qiao, Tianyu Yang, Kiruba S. Haran, Nenad Nmiljkov
University of Illinois Urbana-Champaign, USA

Temperature-Dependent Demagnetization of Nd-Fe-B Magnets for Electrified Vehicles
Peng Peng1, Julia Zhang1, Wanfeng Li2, Franco Leonardi2, Chuanbing Rong2, Michael W. Degner2, Feng Liang2, Leyi Zhu2
1The Ohio State University, USA; 2Ford Motor Company, USA

Design of the High-Efficiency IPMSM considering the Operating Points with Different Characteristics
Soo-Gyung Lee, Min-Ro Park, Kyong-Soo Cha, Jae-Hyun Kim, Jung-Pyo Hong
Hanyang University, Korea (South)
EXHIBITORS

Advanced Test Equipment Rentals
Advanced Test Equipment Rentals is a worldwide leading rental company of test and measurement equipment. We provide a robust selection of the latest technology available through short- and long-term rental options, and for sale. Advanced Test Equipment Rentals is also A2LA ISO 17025 accredited for calibrations offering calibrations on the largest scope of equipment in the industry. You can rely on Advanced Test Equipment Rentals to provide the knowledge, the equipment, and the solutions for your next test equipment needs. We are proud to support the testing world since 1981.

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ANSYS is the global leader in engineering simulation helping the world’s most innovative companies deliver radically better products to their customers. By offering the best and broadest portfolio of engineering simulation software, we help them solve the most complex design challenges and engineer products limited only by imagination.

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HBM
HBM Test and Measurement offers an advanced motor power analyzer designed specifically for electric drive and machine testing producing rapid results including efficiency motor maps, dq0, Space Vector or any custom real-time measurement performed on any signal including multiple torque, speed, CAN, temperature, strain, vibration and over 50 phases of voltage and current all accurately synchronized in a single mainframe. HBM is a leading global supplier of high-performance torque sensors, dynamic power analyzers, data acquisition systems, transducers, sensors, amplifiers and data analysis software.

LC Drives
LC Drives has a developed a revolutionary motor and generator topology that is smaller, more efficient, and ultimately lower cost than conventional machines. This solution has a patented liquid cooled stator that reduces the physical size of the machine by 50% when compared to other water-cooled machines. The core invention is a thermal solution to substantially improve the manner in which heat is removed from the stator winding of the machine. LC Drives has a developed a revolutionary motor and generator topology that is smaller, more efficient, and ultimately lower cost than conventional machines. This solution has a patented liquid cooled stator that reduces the physical size of the machine by 50% when compared to other water-cooled machines. The core invention is a thermal solution to substantially improve the manner in which heat is removed from the stator winding of the machine. LC Drives has a developed a revolutionary motor and generator topology that is smaller, more efficient, and ultimately lower cost than conventional machines. This solution has a patented liquid cooled stator that reduces the physical size of the machine by 50% when compared to other water-cooled machines. The core invention is a thermal solution to substantially improve the manner in which heat is removed from the stator winding of the machine.

Magneforce Software
MagneForce Software Systems produces software for design and simulation of rotating electric machinery. MagneForce products combine Finite Element techniques together with various time based circuit models to provide a total electric machine design environment. Analysis of both the machine and the associated drive/load circuitry allows MagneForce to produce both steady-state and transient results. Unlike general purpose FE packages MageneForce simulators compute directly machine performance parameters such as voltages, currents, torque, power and efficiency. Output from MagneForce simulators also consists of the entire set of machine magnetic parameters including inductances, flux density distributions, demagnetization plots and iron loss distributions. This is all done in an easy to learn and use Windows environment.
MDL
Motor Design Ltd (MDL) is a world leader in developing advanced software and tools for electric machine design. We have been developing electric motor design software since 1998. Our software, Motor-CAD, is recognised worldwide as class-leading motor design software and we use our expert knowledge of designing electric motors to provide software support to electric machine designers at some of the most prestigious aerospace, automotive and industrial companies worldwide.

Plexim
Plexim provides solutions for the design and test of power electronic systems and their associated controls. Its flagship offering is the modeling software PLECS, available in the MATLAB/Simulink environment and as an independent platform. PLECS, known for its fast speed and robustness, includes a comprehensive component library comprising thermal, magnetic, and mechanical domains. The RT Box is a real-time simulation platform designed for Hardware-in-the-Loop (HIL) testing and Rapid Control Prototyping (RCP) that fully integrates into the PLECS software environment. The PLECS processor-in-the-loop (PIL) tool allows co-simulation of embedded code with an offline plant model.

Teledyne LeCroy
Teledyne LeCroy is a leading manufacturer of advanced oscilloscopes, protocol analyzers, and other test instruments that verify performance, validate compliance, and debug complex electronic systems quickly and thoroughly. Since its founding in 1964, the Company has focused on incorporating powerful tools into innovative products that enhance “Time-to-Insight”. Faster time to insight enables users to rapidly find and fix defects in complex electronic systems, dramatically improving time-to-market for a wide variety of applications and end markets.

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Established in 1935, Hioki is a respected developer and manufacturer of innovative test and measurement instruments. Hioki is committed to our corporate philosophy: Respect for Humanity and Contribution to Society. Hioki develops our business from the customer’s perspective. Our product list includes: Power Quality Analyzers (PQA); Insulation Testing; Data Acquisition Recorders; Power Demand Meters; Data Loggers; AM Meters; Volt Meters; Clamp-Ons; Digital Multimeters; Meters; Testers; Field Use Measurement Instruments; Electronic Measurement Instruments; Recorders and Automatic Test Equipment.

POWERSYS Inc.
Powersys is a consulting and software company providing global solutions of engineering software and services for industry, research and education in the field of Electrical & Electromechanical Power Systems. Powersys develops and commercializes EMTP-RV software, the most technically advanced software for the simulation and analysis of electromagnetic transients in power systems. By a combination of the best relevant software on the market and our skill staff engineers, we offer to local and global clients the most flexible solution for studies applicable to:

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Altair Engineering
Altair is a leading provider of enterprise-class engineering software enabling innovation, reduced development times, and lower costs through the entire product lifecycle from concept design to in-service operation. Our simulation-driven approach to innovation is powered by our integrated suite of software which optimizes design performance across multiple disciplines encompassing structures, motion, fluids, thermal management, electromagnetics, system modeling and embedded systems, while also providing data analytics and true-to-life visualization and rendering.
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GM
At General Motors, innovation is our north star. As the first automotive company to mass-produce an affordable electric car, and the first to develop an electric starter and air bags, GM has always pushed the limits of engineering.

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• We are committed to an all-electric future.
• 2.6 billion EV miles have been driven by drivers of five GM electrified models, including the Chevrolet Bolt EV.

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