2021 North America JMAG Users Conference

Virtual Edition

July 27 & 28, 2021

Conference program

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Software and Services

JMAG
Simulation Technology for Electromechanical Design

July 27th, 2021

10.30 AM – 11.00 AM: Welcome Note/ Powersys Presentation | **Dr Takashi Yamada**, JSOL & **Olivier Toury, Ved Acharya**, Powersys

Emerging Trends: JMAG in New Age Mobility

11.00 AM- 11.40 AM: Keynote | Testing and Validation of Electromagnetic Systems using JMAG | **Tim Lambert**, Virgin Hyperloop

Electromagnetic devices are critical to the capabilities of the hyperloop system. Force-producing actuators and electromagnetic machines form the basis of the levitation, guidance, propulsion, and braking functions, and JMAG helps us to validate our electromagnetic designs against hardware in test environments, including feedback from materials characterization programs. We demonstrate a rapid toolchain which enables validation processes to achieve a high degree of accuracy on the immediate timescale required in a startup environment.

JMAG Road Map

11.45 AM – 12.25 PM: Development planning of JMAG | **Dr. Takashi Yamada**, JSOL Corporation

JMAG is constantly being worked on to achieve highly accurate and high-speed simulation. JSOL would like to share our progress from the past year including parallel solvers to accelerate speed as well as GUI improvements aiming for increased productivity of analysis workflow. Analysis technologies we are currently focusing on and our plans for incorporation will also be covered in this presentation. Design exploration is an important topic this year. This presentation will detail the present and future of JMAG.

Drive Cycle Analysis using JMAG

12.30 PM – 12.50 PM: Efficiency Maps | **Sainan Xue**, Powersys Inc.

In designing traction motors for electric vehicles, it is not only the performance of the motor itself that is evaluated, but also the energy consumption (electric vehicle fuel consumption) and distance while the vehicle is being driven. JMAG is capable of generating motor efficiency maps which can then be used as is to perform evaluations for drive cycles."

12.55 PM – 1.25 PM: Dynamic Motor Drive: Optimizing Electric Motor Controls to Improve Efficiency | **Zakirul Islam**, Tula Technology

Improving the efficiency battery-electric vehicle powertrains is a key to increase their range per charge and expand transportation electrification. Although the peak efficiencies of electric motors equipped with rare earth magnets exceed 90%, practical drive cycles and powertrain architectures frequently operate outside of the peak efficiency speed/load region. At 10% of the maximum torque of an electric vehicle, efficiency of the electric motor drive is more commonly 70-85%. In addition, the most efficient electric motors use magnets with large content of Neodymium or Samarium, both of which are expensive and have limited sources of supply. Tula's control architecture – called Dynamic Motor Drive (DMD®) – mitigates the light-load efficiency losses of electric motors while simultaneously reducing or eliminating the reliance on rare-earth materials. By using the DMD pulse density strategy for electric motor control, inverter losses and core losses are mitigated. At high loads, experiments have proven efficiency improvements of 2% on induction motors, with more improvements possible at lighter loaded conditions. This study projects similar efficiency improvement for a synchronous reluctance motor drive in the WLTP. Those improvements enable reduced battery size and increased range while lowering total energy consumed, and do not require hardware changes to the motor or vehicle. This work will detail the controls methodology used to achieve those gains, the optimization of motor design for this new control paradigm, and the experimental results of that system in use."

JMAG in Research & Development

1.30 PM – 1.55 PM: Design of a Series Hybrid Variable Flux Motors for Extended Wide-Speed Performance | **MohanRaj Muthuswamy**, Concordia University

This presentation analyses the electromagnetic simulation of 36 slot 6 pole series hybrid variable flux machine (VFM) using JMAG software. The series hybrid VFM with series rare-earth and AlNiCo magnets shows the benefits of high-power capability at high speeds, more stable magnet operation at full load and lower magnetization current requirement. The magnetization and demagnetization of the series hybrid VFM are performed using the JMAG software. The simulated torque and power-speed curves of the series hybrid VFM are analyzed at different magnetization levels.

Efficient Motor Drive Development & Validation

2.00 PM – 2.20 PM: JMAG Toolchain - JMAG RT for high Fidelity modelling | **Dheeraj Bobba**, Powersys Inc.

JMAG-RT enables model-based development with high concurrency, allowing plant design and control design to be performed concurrently. JMAG-RT is a system which generates high-fidelity plant models (JMAG-RT models) in a system level simulation from FEA models. From system design to ECU verification using HILS, JMAG-RT has a wide range of uses.

2.20 PM – 2.45 PM: Rapid Performance Evaluation of JMAG-Designed Motors in a Motor Drive Environment | **Hua Jin**, Powersim

After a motor is designed in JMAG, a designer would typically need to test the designed motor in a drive environment so that the designer can evaluate if the motor performs as expected and iterate the design if necessary. Setting up the drive system with the proper current, torque, and speed control, however, is not trivial considering the motor nonlinearity and the complexity of designing the control loops. Through its link with JMAG and JMAG-RT, PSIM's Motor Control Design Suite makes this process considerably easier. Based on motor parameters and operating conditions, the Design Suite can come up with a functional drive system that is ready to simulate in a matter of minutes. The drive system incorporates advanced motor control algorithms such as Maximum-Torque-Per-Ampere control, field weakening control, and Maximum-Torque-Per-Volt control to maximize the power, efficiency, and speed range. With other features from PSIM, it is also possible to quickly generate and evaluate the efficiency maps of the motor, inverter, and the entire drive system. The Motor Control Design Suite relieves motor designers from the burden of designing the complex drive system and allows them to focus on the motor design and performance optimization.

2.50 PM – 3.15 PM: A Better Way to Design and Test Motor Drives | **Petar Gartner**, Typhoon HIL

Automotive industry has widely accepted Model Based Design (MBD) for control software development; motivated by software's safety critical nature and the need to comply with ISO 26262. The problem in the past was lack of ultra-high fidelity real-time Controller Hardware in the Loop (C-HIL) simulation of inverter and electric motor thus creating a gap in the workflow when evolving a model from Model in the Loop (MIL) and Software in the Loop (SIL) to C-HIL. In this talk we demonstrate Typhoon's ultra-high fidelity motor drive Hardware in the Loop (HIL) simulation with seamless integration with JMAG FEA machine design software. We will show a typical workflow for design and testing of EV drivetrain starting with JMAG FEA motor design, followed by export of spatial-harmonic PMSM motor model, with iron losses included, from JMAG-RT into Typhoon HIL simulation environment, followed by controller Hardware in the Loop simulation in Typhoon HIL HIL404 simulator interfaced with a real Engine Controller Unite (ECU) in the loop. Furthermore, we will briefly describe HIL interface towards the test automation and test management software.

JMAG in Multidisciplinary Approach to Integrated Motor Modeling using GT-SUITE

3.20 PM – 3.45 PM: A Multidisciplinary Approach to Integrated Motor Modeling using GT-SUITE and JMAG | **Jonathan Zeman**, Gamma Technologies

As electric vehicles become increasingly more mainstream, an increasing level of refinement is required for a modern driving experience. As efficiency and NVH targets become increasingly more stringent, an integrated CAE modeling approach is required to predict system behavior early in the development cycle. This integrated CAE approach requires multi-disciplinary modeling, of electromagnetics, mechanics, and thermal systems together. While these analyses may typically be managed by different engineers, or even different departments, there is a growing

need for increased collaboration. This presentation will detail several avenues for increased collaboration of motor integration to improve NVH behavior.

3.50 PM – 4.15 PM: Multiphysics Modeling of Electric Motor Cooling Strategies using Computational Fluid Dynamics and Electromagnetic Finite Element Simulations | **Praveen Srikanth**, Converge

Efficient cooling of the different thermal components is paramount in advancing the design of electric motors in the future. Computational Fluid Dynamics is poised to be a critical tool in accurately characterizing the applicability of the different cooling strategies available for various motor designs. In this presentation, we use a combined Computational Fluid Dynamics/Finite Element Method approach to study two motor designs adopting different cooling strategies. The first study is with an air-cooled switched reluctance motor using coil windings typically used in power tools. The second study showcases an oil drip cooled traction motor with bar windings often used in electric vehicles. In CONVERGE, the volume mesh upon which the governing equations are solved is created automatically and refined dynamically based on the solution at any given time. This enables a highly efficient calculation especially when dealing with complicated geometries with intricate solid components.

4.20 PM – 4.25 PM: Closing Comments for Day 1

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July 28th, 2021

10.30 AM – 10.45 AM: User Conference Introduction | **Olivier Toury, Ved Acharya**, Powersys

Advancements in Material characterization in Motor Analysis

10.45 AM – 11.25 AM: Electric Machine Design for Manufacturability | **Dave Farnia**, Arnold Magnetics

When designing an electric machine, there's more to consider than just performance. What materials are used in the stator and rotor, component testing, cost at high volumes, mechanical tolerances, etc. These are all things that will impact the final product and determine if a design is successful. This presentation will discuss some practical manufacturing considerations for high performance motor design.

11.30 AM – 12.05 PM: Design of an integrated motor drive with a highly saturated high frequency electric machine using JMAG| **Max Liben**, H3X

All-electric aviation is increasingly at the forefront of research and development with the promise of zero-carbon air travel and a 40% reduction in operating costs for short-haul flights. According to the Advanced Research Projects Agency-Energy (ARPA-E), a propulsion system efficiency greater than 93% and specific power greater than 12 kW/kg is required for an electric narrow-body commercial airliner to complete a typical 5-hour flight, which represents a 3x step change over the specific power of commercially available solutions. This presentation will discuss the technology development required to achieve this step change, starting with presenting an alternative framework for the scaling of machine specific power that addresses ubiquitous misconceptions about specific torque and winding current density, continuing to identify areas of performance bottlenecks, and culminating with the materials and manufacturing technologies required to overcome these barriers to performance. Ultimately, an overview will be presented for the design of a synergistically cooled integrated motor drive composed of a highly saturated, high frequency machine with additively manufactured coils and a silicon carbide inverter. Highlights of analysis using JMAG Designer will be included to provide illustrative examples.

JMAG Optimization

12.10 PM - 12.40 PM: Motor Design using topology optimization and parameter optimization | **Dheeraj Bobba**, Powersys Inc.

Realize high output density is required to develop EV traction motors, and conventional experience-based and existing product improvements are becoming unable to reach such higher requirement. Optimization is required to meet higher requirements, and a wide range of design space must be explored all over.

12.45 PM – 1.15 PM: 3D FEA Simulation of a High Torque Density Toroidal Motor | **Maged Ibrahim**, NRC-GC

A novel toroidal motor structure consisting of a rotor wrapped around the stator was designed in order to maximize the electromagnetic interaction within the motor volume. The motor utilizes simple ring-shaped magnets and toroidal concentrated windings with a soft magnetic composite core to enable 3-D flux paths. The proposed design is simulated using 3D electromagnetic and thermal FEA. The simulation results show that the proposed design can achieve at least 40% and 30% higher output torque compared to radial and axial flux PMSMs, respectively. In addition, 3D FEA thermal analysis shows the potential for a highly efficient magnet cooling that can enhance the motor reliability at high loading conditions and enable the possibility of using lower grade magnets.

1.20 PM – 1.50 PM: Modular Multiphase AC Motor Drive for Fault-Tolerant Operation | **Matt Lee**, MSU

In recent years, electric power conversion systems have drawn a lot of attention due to rapidly growing interests in transportation electrification and distributed energy system (DER). High-performance power electronics, batteries, and electric machines are the key enabling technologies for accelerating this trends, and significant efforts have been devoted to developing more efficient, reliable, and cost-effective power conversion systems. This research aims to shed light on reliability of motor drive systems for safety-critical applications such as hybrid electric/electric vehicles, off-road vehicles, electrified aircrafts, and ships.

A modular multiphase fault-tolerant motor drive topology with a new vector control technique is proposed to achieve extremely high-level of reliability and performance. The design and operation of the proposed fault-tolerant motor drive are validated analytically, and investigated by extensive simulations (circuit, control, and motor FEA), followed by experimental verification. It has been analytically and experimentally verified that the proposed fault-tolerant motor drive can tolerate up to four-phase open-circuit faults and two-phase short-circuit faults. Several new open- and short-circuit fault compensation strategies have been proposed and investigated in detail.

Efficient Multi-Physics Approach to Design of electric drive

1.55 PM – 2.20 PM: JMAG Force/Loss Computation | **Dheeraj Bobba**, Powersys Inc.

2.20 PM – 3.05 PM: Keeping eMotors efficient, cool and silent | **Alexis Talbot**, Hexagon

Designing an electric motor requires to balance different performance aspects such as efficiency, Noise and vibrations, cooling and durability. To perform such balanced optimization efficiently, numerical simulation offers great capabilities to evaluate at each design refinement the effect of design changes on these different attributes. During this presentation from Hexagon simulation experts, we will demonstrate how software such as scFLOW, Romax and Actran can be used in conjunction with JMAG to predict the electric motor performances.

JMAG Advanced Features

3.10 PM – 3.45 PM: JMAG New Features and Improvements | **Sainan Xue**, Powersys Inc.

3.50 PM – 4.00 PM: End of Conference - Closing Remarks

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Contact us: marketing@powersys.fr