Design & Optimization of High Torque Density Permanent Magnet Synchronous Machines with Optimal Weakening for Traction Applications

SPEAKERS

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About The Speakers:

***Mohanraj Muthusamy*:**
Mohanraj Muthusamy currently serves as an electromagnetic design engineer at Powersys in Montreal, Canada. He received his PhD in Electric Machine Design from Concordia University in Montreal, Canada. His research focuses on innovative magnetic materials, additive manufacturing, and loss-measuring techniques to enhance the efficiency and torque density of electric motors. He has also gained experience as a part-time magnetic designer at Dana TM4 in Montreal, Canada and as an electric machines research engineer at PSG College of Technology in Coimbatore, India.

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Ved Acharya is currently working as Engineering Manager at Powersys in San Diego, CA. He obtained his master's degree in electrical engineering from UNC Charlotte, USA. His research focus includes magnetic gears & electrical machines.

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Dheeraj Bobba is currently a Senior Electromagnetic Design Engineer at Powersys in Madison, WI. He obtained his PhD in Electrical Engineering and the University of Wisconsin – Madison and has held positions as Software Developer and Applications Engineer focusing on low-frequency electromagnetics in the past. His current research interests include high power density electric machine design, control, and optimization techniques focusing on traction and aerospace applications.

ABSTRACT

Electric machines play an important role in traction applications; high torque and high-power density are important aspects that must be considered while designing an electric machine. This tutorial will emphasize practical design considerations, trade-offs, and design procedures to meet the required technical specifications of an electric motor using the JMAG FEA package. The tutorial will have three different parts. The first part presents the fundamental design of an electric machine, which includes the selection of slot/pole, and the selection of machine parameters such as overall diameter, stack length, magnet dimensions, turns per coil, parallel path, current density and flux density.

The second part presents the benchmarking of the Toyota Prius (2010) electric motor, and it presents the design steps of an example electric motor to meet the Toyota Prius (2010) specifications by considering the fundamental design aspects presented in the first part. Also, it presents the comparison of cogging torque, phase back EMF, average torque, torque ripple, and the characteristic current requirement to achieve optimal flux weakening for two different slot/poles which are designed to meet Toyota Prius specifications.

It also includes the efficiency map comparison at the base speed and maximum speed for both the slot/pole designs. The best slot/pole combination is selected for further analysis. The third part focuses on the coupled multi-physics-based (electromagnetic and structural) multi-objective parametric optimization for the selected best/slot pole to improve the electromagnetic performance of the motor. Finally, it compares electromagnetic performances between the initial and optimized designs.