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Tutorial Title

Advancements in Digital Design and Manufacture of Electric Propulsion Motors

Instructor Team

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Abstract

Electric propulsion is widely seen one of the main solutions to improve energy efficiency and reduce CO2 emissions in transportation. Whether hybrid or full electric future propulsion systems will undoubtedly require power electronic driven electrical machines. Industry-led technology road maps across automotive, aerospace, heavy goods transport etc. sectors recognise the importance of electrification and have set demanding targets on future electrical machine power to weight, efficiency and cost, alongside considerations of security of material supply chain and local manufacturing capabilities. Further there is a growing skills shortage in experienced engineers with a knowledge of electrical systems, stifling opportunities for growth and innovation.

There is a strong interest to reduce the volume and cost of active materials in propulsion motor technologies beyond their current state-of-art. Potential solutions include increased motor speeds and higher pole numbers and/or typologies such as reluctance and induction machines with reduced dependence on rare-earth materials. In high performance, weight critical applications such as aircraft the limitations of conventional electrical machine construction, comprising laminated iron and organic polymer insulated magnet wire coils, is becoming a major barrier to future performance improvement. Reliability and longevity are also emergent considerations, particularly in understanding the impact of the adoption of new designs, materials and manufacture where there is not an established knowledge base or experience. As there can be significantly different usage and performance requirements across e-mobility applications adopting a common standard of motor design is unlikely to yield the optimum in terms of overall system energy efficiency and cost. Design software needs to become increasingly sophisticated to cater for the new technological development and in providing a valuable experience for potentially non-specialist users. These considerations will be discussed and compared.

In particular the tutorial will explore the prospects of advancements in new materials and net shaped manufacture alongside computational intelligence in addressing the challenges of an increasingly digital design environment. Automotive and aerospace case studies covering a range of new developments will be outlined, to include:

- How cutting-edge sensitivity analysis and multi-objective optimisation techniques can be applied in the design of an electric propulsion motor. The accessibility of a high performance or cloud computing infrastructure is capable of delivering a truly revolutionary design workflow, allowing multiple candidate solutions to be evaluated in terms of electromagnetic, thermal and mechanical behaviour across the full operating envelope.
- The potential of metal additive manufacture in reducing loss in high frequency windings and in providing integrated thermal management. The design chain of computational efficient modelling of 3D winding structures, 3D printing process, conductor post treatment and insulation will be explained.
- Developmental trends of composites with directional thermal, mechanical and electromagnetic properties suitable for electrical machines. How X-ray tomography, common in the composite inspection, can be used to assess manufacturing variability and degradation in electrical machine windings.

Instructor Biographies

The Instructor Team are experienced in the organization and presentation of tutorials and short courses to industry and academia. These include previous IEEE conference Tutorials, the most recent at ECCE21, Vancouver.

Prof. Philip H. Mellor, (M'12) received the B.Eng. and Ph.D. degrees in electrical engineering from The University of Liverpool, Liverpool, U.K., in 1978 and 1981, respectively. He is currently a Professor with the Department of Electrical and Electronic Engineering, University of Bristol, Bristol, U.K. Prior to this, he held academic posts with The University of Liverpool, from 1986 to 1990, and The University of Sheffield, Sheffield, U.K., from 1990 to 2000. Dr Mellor has published over 300 papers, the majority in IEEE Proceedings and affiliated conferences. His research interests are in the electromagnetic design and thermal management of high-efficiency electric drives and actuation and generation systems for application in aircraft and electric vehicles.

Dr. Nick Simpson, (M'14) received the B.Eng. and Ph.D. degrees in electrical engineering from the University of Bristol, Bristol, U.K., in 2009 and 2014, respectively. He is currently a Senior Lecturer with the Department of Electrical Engineering, University of Bristol and holds a UKRI Future Leader Fellowship exploring the role of digital design and manufacture in electrical machines. His research interests include the modeling, manufacture, and characterization of electrical machines, and wound passive components, primarily for more electric aircraft and electric vehicle applications.

Dr. Mircea Popescu, (M'98 – SM'04 – F'14) is Principal Product Specialist for Motor Design Ltd, Ansys UK and has more than thirty five years of engineering experience. Earlier in his career, he was with Helsinki University of Technology (now Aalto University) in Finland, SPEED Lab at University of Glasgow, UK and Motor Design Ltd., UK. He published more than 150 papers and his publications have received three IEEE best paper awards. At Ansys, he is responsible for electrical machines program innovative developments. An IEEE Fellow, Dr. Popescu was 2014-2015 Chair of the IEEE IAS Electrical Machines Committee and 2013-2016 Prominent Lecturer IEEE IAS Region 8.

Dr. Melanie Michon, is Senior Manager Application Engineering for Motor Design Ltd, Anys UK. Melanie has gained a PhD degree in Electrical Engineering from the University of Sheffield. She has 20 years of combined academic and industrial experience enabling her to provide thought leadership and to drive innovation with a clear focus on IP development and commercialization. At Ansys, she heads the electrification programs and application engineering team and technical pre-sales support. Her previous posts include Head of Electrification at Motor Design Ltd and Romax Technology, where she has successfully established a Centre of Excellence for Electrification, delivering electrical machine design and novel electro-mechanical analysis solutions.

Dr. Josh Hoole, received the MEng and PhD degrees in Aerospace Engineering from the University of Bristol, Bristol, UK in 2016 and 2020 respectively. He is currently a Lecturer in Systems Engineering and a member of the Electrical Energy Management Group at the University of Bristol, Bristol, UK. His research interests include the characterization and modeling of conductor lay and AC loss variability in electrical machine windings. To date, this is focused on the exploitation of x-ray computed tomography of as- manufactured windings.