**EPE'23 ECCE Europe – Call for Tutorials**

# DESIGN OF HIGH-PERFORMANCE POWER ELECTRONIC MOTOR DRIVES USING STATE-OF-THE-ART WIDE BANDGAP DEVICES

## Name(s) and Affiliation(s) of the Lecturer(s):

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## Tutorial Objectives:

The efficiency of electric motor drives is becoming important because, in many applications, efficiency is a premium attribute. For example, in electric vehicles, 1% less loss in a power electronic drive can yield 1% less battery for the same desired range of the vehicle. Most recently, with the advance of state-of-the-art wide bandgap devices, the efficiency of the motor controller can be increased significantly compared to using Si devices such as IGBTs. Hence, this tutorial aims at the efficiency and high-performance aspects of motor drives for many applications, including electric vehicles.

The introduction of wide bandgap devices can also create adverse effects. For example, EMI/EMC emissions may increase, bearing current issues can become critical, or ringing in motor terminals may become more pronounced. How to design motor controllers using these new devices is a meaningful comparison.

In this tutorial, we will review the state-of-the-art wide bandgap devices and provide insights on designing both voltage source inverters (VSI) and current source inverters (CSI). Their CMI EMI emissions will be compared. A new "balanced inverter" topology will be introduced for CSI, and a new H7 topology will be presented for CSI. It will be shown that with a new modulation scheme for H7-CSI, an efficiency increase of up to 3% will be achieved by using bi-directional (BD) switches compared to the conventional H6-CSI topology will be presented. Finally, VSI and CSI topologies will be compared using many vital characteristics.

## Target Audience:

The targeted audience is people interested in designing and applying power electronic motor controllers using wide bandgap (WBG) power electronic devices. The audience should have a fundamental knowledge of power electronics. This presentation would be interesting for the audience such as:

- Graduate student and junior researchers in relevant areas.
- Industrial engineers and scientists in relevant sectors.
- Senior engineers and scientists that are working in other fields and interested in motor drives.

**Topical Outline: (Total of 180 Minutes and 30 min Cofee Break)**

**Introduction: (Estimated time: 5 minutes)**

- Introduction of Speaker and Tutorial

**Overview: (Estimated time: 30 minutes)**

- Overview of Wide bandgap Devices
  - SiC Devices
  - GaN Devices
  - Monololitic bi-directional devices

**Real Tutorial, Theme 1, Benefits and Challenges of Voltage Source Inverters using WBG (Estimated time: 60 minutes)**

- Example of 2-level Inverters using SiC and GaN devices
- Benefits of SiC and GaN Devices
- Challenges of SiC and GaN devices on 2-level inverters
  - EMI
  - Bearing current
  - Voltage Ringing
  - Voltage isolation
- 3-level Inverters using WBG devices
  - Examples
  - Benefits
  - Challenges
  -
- SiC Devices – State-of-of-the art
- GaN Device – State-of-of-the art
- Challenges using SiC and GaN Devices (Voltage overshoots, motor insulation, bearing current issues)
- Bi-directional switches and their application to Matrix Converters, T converter, and Current Source Inverters
- Monolithic Bi-Directional Switches – New developments in the field

**Real Tutorial, Theme 2, Benefits and Challenges of Current Source Inverters using WBG (Estimated time: 60 minutes) (Estimated time: 60 minutes)**

- What is a CSI, i.e. H6 topology?

- Why are CSIs back in the modern age of power electronics?
- How is the dc link inductor reduced in CSI due to WBG device usage?
- Examples of CSI design including dc link inductor design with high-frequency ripple
- Frond end for CSI – Current Source Rectifiers
- Improvements of CSI using H7-topology
- Detailed comparison of CSI and VSIs

**Conclusions (Estimated time: 5 minutes)**

- The conclusion will summarize the benefits and challenges of WBD devices as applied to VSIs and CSIs

**Provisional Schedule of the Tutorial:**

Schedule:

13:00 – 14:30 : Introduction / Theme 1
14:30 – 15:00 : Coffee break
15:00 – 16:30 : Theme 2 / Conclusions

**About the Lecturer:**

**Bulent Sarlioglu** is a Professor with the University of Wisconsin-Madison and the Associate Director of the Wisconsin Electric Machines and Power Electronics Consortium. From 2000 to 2011, he was with Honeywell International Inc.'s Aerospace Division, Torrance, CA, USA, most recently as a Staff Systems Engineer.

His expertise includes electrical machines, drives, and power electronics, with a particular emphasis on electrification of transportation and industrial applications. He is the inventor or co-inventor of 20 U.S. patents and many international patents. In addition, he has more than 200 technical papers that are published in conference proceedings and journals. Dr. Sarlioglu was the recipient of Honeywell's Outstanding Engineer Award in 2011 for his outstanding contribution to aerospace, the NSF CAREER Award in 2016, and the 4th Grand Nagamori Award from Nagamori Foundation, Japan, in 2018.

Dr. Sarlioglu involves in many IEEE activities. He currently serves as the Chair of the PES Motor Subcommittee, Chair of the IAS Transportation Committee, Educational Activity Chair of the PELS TC4 Electrical Transportation Systems, and one of the co-editors of the IEEE Electrification Magazine. Dr. Sarlioglu was nominated and selected to become a Distinguished Lecturer for the IEEE Vehicle Technology Society (2021-Present) and IEEE Industrial Application Society (2019-2021). Dr. Sarlioglu received the IEEE PES Cyril Veniott Award in 2021. Dr. Sarlioglu became a fellow for the National Academy of Inverters in 2021 and an IEEE Fellow in 2022.