Reflective Wave Mitigation for SiC Motor Drive

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

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Tutorial Objectives:

In this paragraph, please describe the tutorial objectives of the tutorial that you propose. Please make sure the objectives are clearly described.

SiC motor drives can achieve higher efficiency and higher power density which has been already applied to electric vehicles in the market. However, for electric ship and electric aircraft applications with longer cables, the overvoltage at motor terminals due to reflected wave phenomenon (RWP), which is recognized as a main source of premature winding insulation failures in drive systems, becomes more challenging due to the higher dv/dt of SiC devices leading to the RWP occurring in a motor drive system at shorter cable length. For instance, the overvoltage ratio at the motor terminal increased from 20% to 100% when PWM voltage rise time decreased from 200 to 25 ns with only 20 feet of the cable length. The traditional methods to solve this issue are no longer attractive solutions for SiC motor drives due to their higher losses caused by higher switching frequency of SiC motor drives. In this tutorial, both passive and active methods from industry and academia to mitigate the overvoltage caused by SiC devices are introduced covering a wide range of motor drives from 2-level to multilevel topologies. Moreover, these new techniques can also be applied to conventional IGBT motor drives with longer cables.

Target Audience:

In this paragraph, please describe the target audience of the tutorial that you propose. Please make sure the target audience is clearly described.

Transportation electrification plays a critical role in the decarbonization mission. Both industry and academia are developing SiC motor drives for transportation applications to achieve this goal. This tutorial topic will help solve one of the biggest challenges that SiC motor drives are facing, therefore will attract transportation industries especially the aviation and ship sectors as well as academia.

Topical Outline:

Introduction: (Estimated time: 30 minutes)

- Introduction, reflective wave phenomenon in motor drives
- Introduction, SiC motor drive deteriorating reflective wave phenomenon
- Challenges for MVDC power conversion systems

Overview: dv/dt limiter technology review (Estimated time: 20 minutes)

- Overview, passive dv/dt limiter
- Overview, active dv/dt limiter
- Overview, reflective wave cancelation techniques

Real Tutorial, Theme 1: Design and optimization of passive dv/dt filters for SiC motor drives (Estimated time: 30 minutes)

- Development of RLC dv/dt filter for MW-scale aircraft propulsion drives
- Multi-domain optimization of dv/dt passive filters for high-frequency aviation applications
- Summary

Real Tutorial, Theme 2: Reflective wave cancelation techniques for 2-level SiC motor drive (Estimated time: 20 minutes)

- The cancellation principle for 2-level motor drive
- The reflective wave canceller design for 2-level motor drive
- Experimental verifications

Real Tutorial, Theme 3: Reflective wave cancelation techniques for multilevel SiC motor drive (Estimated time: 30 minutes)

- The cancellation principle for multilevel motor drive
- The reflective wave canceller design for multilevel motor drive
- The reflective wave canceller design for MMC motor drive
- Simulation and experimental verifications
- Summary

Real Tutorial, Theme 4: Adaptive surge impedance for long-cable-fed motor drives (Estimated time: 30 minutes)

- New concept introduction
- Modeling and simulation
- Hardware implementation
- Experimental characterizations
- Summary

Conclusions (Estimated time: 20 minutes)

- Conclusion 1 (Jiangbiao – Passive dv/dt filters)
- Conclusion 2 (Helen/Yu – Reflective wave canceler)
- Q&A

Provisional Schedule of the Tutorial:

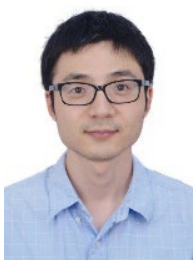
Schedule:

90-min: Introduction / Theme 1 / Theme 2
15-min: Coffee break / Lunch Break
90-min: Theme 3 / Theme 4 / Conclusions

About the Lecturers:

Hui "Helen" Li is a professor of Electrical and Computer Engineering Department and leads power electronics research at Center for Advanced Power Systems (CAPS), Florida State University. Her current research focus is on medium-voltage power electronics for transportation and grid applications enabled by WBG device including and not limited to motor drive, solid-state transformers, gate drivers, active and passive EMI filters, model predictive control, etc. She is co-editor-in-chief of IEEE Transaction on Power Electronics from 2019-2021. She is a PELS Distinguished Lecturer of 2018-2019 and 2020-2021. She is the elected member at large of Administrative Committee of PELS from 2011-2013, 2015-2017, 2018-2020. She is a Fellow of the IEEE. She is Provost McKenzie Professor at FSU.

JiangBiao He is with the Department of Electrical and Computer Engineering, University of Kentucky, USA. He previously worked in industry, most recently as a Lead Engineer at GE Global Research, Niskayuna, New York. He also worked at Eaton Corporation and Rockwell Automation before he joined GE in 2015. He received the Ph.D. degree in electrical engineering from Marquette University, USA. His research interests include transportation electrifications particularly on electric aircraft propulsion, renewable energies, and fault-tolerant electric power apparatuses for safety-critical applications. He has authored and co-authored over 120 technical papers and 10 U.S. patents. He is an IEEE Senior Member, and has served as an Editor or Associate Editor for several prestigious IEEE journals in the electric power area. He also served in various roles in the organizing committees for numerous IEEE conferences, and has been an active member of multiple IEEE standards working groups. He is the recipient of the 2019 AWS Outstanding Young Member Achievement Award recognized by the IEEE Industry Applications Society.



Yu Zhang received the B.S. and M.S. degree from Xidian University, Xi'an, China, in 2012 and 2015, respectively, and the Ph.D degree from Florida State University, Tallahassee, FL, USA in 2021, all in electrical engineering.

He is currently an associate professor in the College of Mechano-Electronic Engineering, Xidian University, Xi'an, China. His main research interests include reflected wave phenomenon, filter design and electromagnetic compatibility, especially for WBG converters.