

Tutorial Title

Reflective Surge Voltage Mitigation for Fast-Switching Motor-Drive Systems

Instructor Team

Team Chair: Hui “Helen” Li, Florida State University, USA

Co-Speakers: JiangBiao He, University of Kentucky

Ranga Tallam, Rockwell Automation

Yu Zhang, Xidian University

Abstract

Wide bandgap (WBG) switches such as Silicon Carbide (SiC) or Gallium Nitride (GaN) devices enable motor-drive systems with higher efficiency and higher power density, which is very beneficial for efficiency sensitive or weight/volume sensitive industry sectors such as electric vehicles. However, for many other applications with longer cables interconnected between the motors and inverters (e.g., electric ship and electric aircraft), the overvoltage at motor terminals due to reflected wave phenomenon (RWP) becomes more challenging due to higher dv/dt of WBG semiconductor devices and higher voltage levels of the high-power systems (e.g., MVDC or HVDC). On the other hand, stator winding insulation failures are the most common failures in electric machines, especially for medium-voltage or high-voltage systems operating at high altitude. Thus, it is indispensable to develop effective solutions for surge voltage mitigation in fast-switching long-cable-fed motor-drive systems. This seminar provides in-depth coverage of RWP mitigation methods from industry and academia to suppress the high-frequency overvoltage in long-cable-fed motor drive applications. The seminar begins with an introduction to the fundamental operating principles of RWP, traditional mitigation methods for Silicon IGBT motor drives and challenges for WBG motor drives. The latest advancements in mitigation for WBG motor drives is overviewed including passive filter methods and active filter methods. Furthermore, two promising methods for SiC motor drives will be presented in detail, including an optimization design of passive dv/dt filter and a compact design of active reflected wave canceller (ARWC). The principles, key design aspects and power loss in specific design scenarios will be discussed in detail respectively. Finally, various mitigation solutions in Rockwell industrial variable-frequency drives will be presented. This academic-industrial joint seminar is very suitable for electrical engineers and researchers who are developing motor drives for various applications, not only using WBG devices but also Si devices, since these new techniques can also be applied to conventional IGBT-based motor drives.

Instructor Team Biographies

Hui “Helen” Li is a professor in electrical engineering 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 a Fellow of the IEEE. She is Provost McKenzie Professor at FSU.

JiangBiao He is an associate professor in electrical engineering at the 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 focus on advanced power electronics and motor-drive systems for transportation electrifications and renewable energies. He has authored and co-authored around 150 technical papers and 10 U.S. patents. He has given multiple tutorials in prestigious IEEE conferences such as APEC-2019 and ECCE-2021. He is the recipient of the 2018 GE-GRC Whitney Technology Excellent Award and 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.

Ranga Tallam received the Ph.D. degree in electrical engineering from the Georgia Institute of Technology, Atlanta, USA, in 2001. He is currently Senior Manager for Power Electronics HW Development with Rockwell Automation in Mequon WI. He leads a team of engineers working on research, product development, and application of ac drives. He is the holder of 20 U.S. patents. His research interests are in switching power converter technology, motor control and diagnostics, and ac drives. In 2012, he was recognized as the Rockwell Automation Engineer of the Year for the development of a new high-power AC drive.