

Announcement for a Tutorial at EPE 2017 ECCE Europe

Title

Small-Signal Stability and Subsystem Interactions in Distributed Power Systems with Multiple Converters

Presenting Speakers

Dushan Borojevich, Virginia Polytechnic Institute & State University

Jinjun Liu, Xi'an Jiaotong University

Paolo Mattavelli, University of Padova

Rolando Burgos, Virginia Polytechnic Institute & State University

Zeng Liu, Xi'an Jiaotong University / Virginia Polytechnic Institute & State University

Scope and Benefits

One of the major developing trends of distributed power systems, no matter in stand-alone form or in public grid form, is that more and more electronic power converters are adopted for the purpose of power conditioning or performance improving. This has been leading to quite a few technical challenges, one of them being the small-signal stability issue, which is caused by the dynamic interactions among subsystems/converters and is quite different from the stability issue with conventional power grids. A review of existing analytical approaches to deal with this issue is presented, including traditional power system approach and some power electronics background approaches proposed recently. It turns out that the impedance-based approach is an appropriate analytical approach for such stability issue. The tutorial will then be focused on an in-depth review of existing and recent work of impedance-based approaches for DC system stability and AC system stability. The content of the tutorial is quite abundant therefore is organized into two consecutive parts. The two parts are very tightly related, with Part 1 being as the fundamental theories and approaches, and Part 2 being as the details of the implementations and applications. Timewise, the tutorial is planned to be a full day program covering a morning session (Part 1) and an afternoon session (Part 2). Each session will be about 3 hours and a half with short breaks included. The authors carefully organized all the available material, and intentionally chose the fully day duration instead of compressing all the material into a half-day form, in order to be not superficial and to provide sufficient practical insights and solutions to the audience.

Contents

Monday, 11 September 2017 - Tutorial day (Location: WUT, Warsaw, Poland)

08:00 - 09:30 Registration for full day and morning **Tutorials**

09:30 - 13:00 **Tutorial Part 1: Theories and Approaches**

- 1 Introduction (10 minutes)
- 2 Small-signal terminal modeling of converters and Impedance-based system stability analysis (10 minutes)
- 3 Impedance-based stability criteria and online monitoring (10 minutes)
- 4 A classification of subsystems based on terminal characteristics and a modification of stability criterion for two cascaded subsystems (20 minutes)
- 5 Stability criteria for two parallel subsystems based on the proposed classification (20 minutes)
- 6 Impedance-based stability criteria for multiple subsystems (20 minutes)

11:00 - 11:30 Coffee break

- 7 What if interactions also exist through communications like active current sharing (20 minutes)
- 8 Migration to three-phase AC systems: modeling and analysis approach (70 minutes)
 - 1) Introduction of three-phase AC systems (5 minutes)
 - 2) DQ Impedances of three-phase AC system (20 minutes)
 - 3) Small-signal stability analysis using Generalized Nyquist Criterion (GNC) (30 minutes)
 - 4) Extension to single-phase AC systems (10 minutes)
 - 5) Single-phase models for three-phase systems (5 minutes)

13:00 - 14:00 Lunch break and registration for the afternoon tutorials

14:00 - 17:30 **Tutorial Part 2: Implementations and Applications**

- 1 Impedance measurements of DC and AC systems (30 minutes)
- 2 Dynamic interactions in high power factor systems (20 minutes)
- 3 Phase-locked loop (PLL) dynamic effect on impedance (20 minutes)
- 4 PLL-related stability issues in converter systems (20 minutes)

15:30 - 16:00 Coffee break

- 5 Stability assessment in MV distribution systems and HV systems (20 minutes)
- 6 Stability prediction of droop-controlled parallel inverters (30 minutes)
- 7 Possible simplifications on Generalized Nyquist Criterion (20 minutes)
- 8 Underminated model of three-phase systems/Other Topics (20 minutes)

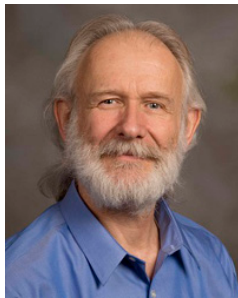
Who Should Attend

Engineers, graduate students and academia faculties who are interested in the issue and effective solutions on the stability of power systems with multiple electronic power converters.

Technical Level: The technical level of the tutorial shall be intermediate and above, however beginners on this topic shall also feel not too difficult.

About the Instructors

Dushan Borojevich



Dushan Borojevich received the Dipl.Ing. degree from the University of Belgrade, Belgrade, Serbia (formerly Yugoslavia), in 1976, the M.S. degree from the University of Novi Sad, Novi Sad, Serbia, in 1982, and the Ph.D. degree from Virginia Polytechnic Institute and State University (Virginia Tech), Blacksburg, VA, USA, in 1986.

From 1986 to 1990, he was an Assistant Professor with and the Director of the Power and Industrial Electronics Research Program, Institute for Power and Electronic Engineering, University of Novi Sad, where he later became the Acting Head of the institute. He then joined the Bradley Department of Electrical and Computer Engineering, Virginia Tech, as an Associate Professor. He is currently the American Electric Power Professor with the same department, where he is also the Co-director of the Center for Power Electronics Systems. His research interests include multiphase power conversion, electronic power distribution systems, power electronics systems modeling and control, and the integrated design of power converters.

Dr. Borojevich was the President of the IEEE Power Electronics Society from 2011 to 2012. He is a member of the U.S. National Academy of Engineering. He was a recipient of the IEEE William E. Newell Power Electronics Technical Field Award and IEEE Power Electronics Society's Harry A. Owen Distinguished Service Award.

Jinjun Liu



Jinjun Liu received his B.S. and Ph.D. degrees in Electrical Engineering from Xi'an Jiaotong University (XJTU), China in 1992 and 1997 respectively.

He then joined the XJTU Electrical Engineering School as a faculty. From late 1999 until early 2002, he was with the Center for Power Electronics Systems at Virginia Polytechnic Institute and State University, USA, as a visiting Scholar. In late 2002 he was promoted to a Full Professor and then the head of the Power Electronics and Renewable Energy Center at XJTU. He

currently holds the position of XJTU Distinguished Professor of Power Electronics, sponsored by Chang Jiang Scholars Program of Chinese Ministry of Education. His research interests are power quality control and utility applications of power electronics, micro-grids for sustainable energy and distributed generation, and more/all electronic power systems.

Dr. Liu received for 7 times governmental awards at national level or provincial/ ministerial level for scientific research achievements or academic/teaching career achievements. He also received the 2006 Delta Scholar Award, the 2014 Chang Jiang Scholar Award, and the 2014 Outstanding Sci-Tech Worker of the Nation Award, and the IEEE Transactions on Power Electronics 2016 Prize Paper Award.

Dr. Liu has served as the IEEE Power Electronics Society (PELS) Region 10 Liaison and then China Liaison for 10 years, an Associate Editor for the IEEE Transactions on Power Electronics for 10 years, and starting from 2015 the Vice President for membership of IEEE PELS. He is on Board of China Electrotechnical Society (CES) and was elected to a Vice President of the CES Power Electronics Society in 2013. He has been the Vice President for International Affairs, China Power Supply Society (CPSS) since 2013 and the inaugural Editor-in-Chief of CPSS Transactions on Power Electronics and Applications since 2016.

Paolo Mattavelli

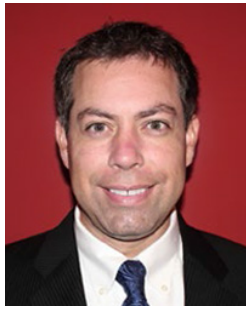


Paolo Mattavelli received the Ph. D. degree in electrical engineering from the University of Padova (Italy) 1995. From 1995 to 2001, he was a researcher at the University of Padova. From 2001 to 2005 he was an associate professor the University of Udine, where he led the Power Electronics Laboratory. In 2005 he joined the University of Padova in Vicenza with the same duties. From 2010 to 2012 he was a professor and member of the Center for Power Electronics Systems (CPES) at Virginia Tech. He is currently (2015) a professor at the University of Padova, leading the Power Electronics Lab. in Vicenza.

His major field of interest includes analysis, modeling and analog and digital control of power converters, grid-connected converters for renewable energy systems and micro-grids, high-temperature and high-power density power electronics. In these research fields, he has been leading several industrial and government projects.

From 2003 to 2012 he served as an Associate Editor for IEEE Transactions on Power Electronics. From 2005 to 2010 he was the IPCC (Industrial Power Converter Committee) Technical Review Chair for the IEEE Transactions on Industry Applications. For terms 2003-2006, 2006-2009 and 2013-2015 he has been a member-at-large of the IEEE Power Electronics Society's Administrative Committee. He also received in 2005, 2006, 2011 and 2012 the Prize Paper Award in the IEEE Transactions on Power Electronics and in 2007, the 2nd Prize Paper Award at the IEEE Industry Application Annual Meeting. He is an IEEE Fellow.

Rolando Burgos



Rolando Burgos received the B.S. degree in electronics engineering, the Electronics Engineering Professional Degree, and the M.S. and Ph.D. degrees in electrical engineering from the University of Concepción, Concepción, Chile, in 1995, 1997, 1999, and 2002, respectively.

In 2002, he joined the Center for Power Electronics Systems (CPES), Bradley Department of Electrical and Computer Engineering, Virginia Polytechnic Institute and State University (Virginia Tech), Blacksburg, VA, USA. In 2009, he joined ABB Corporate Research, Raleigh, NC, USA. In 2012, he returned to Virginia Tech, where he is currently an Associate Professor with the Bradley Department of Electrical and Computer Engineering and a faculty member with CPES. His research interests include multiphase multilevel power conversion, grid power electronics systems, the stability of alternating-current and direct-current power systems, high-power-density power electronics, modeling, and control theory and applications.

Dr. Burgos is a Member of the IEEE Power Electronics Society, the IEEE Industry Applications Society and the IEEE Industrial Electronics Society.

Zeng Liu



Zeng Liu received his B.S. degree from Hunan University, China, and his M.S. and Ph.D. degrees from Xi'an Jiaotong University (XJTU), China, in 2006, 2009 and 2013 respectively, all in electrical engineering. He then joined XJTU as a faculty, where he is currently an associate professor with school of Electrical Engineering. Since September 2015, he has been with the Center for Power Electronics Systems at Virginia Polytechnic Institute and State University, USA, as a visiting scholar. His research interests include control of distributed generators and microgrids, small-signal modeling and stability analysis of AC power electronics systems, impedance measurement of AC systems. Dr. Liu is a Member of the IEEE Power Electronics Society.