

**13th International Symposium
Power Electronics for Distributed Generation Systems (PEDG 2022)
June 26-29, 2022 | Kiel, Germany**

Tutorial Proposal

Title of the Proposal: Power Quality and Protection in Microgrids

- Presenters

Dr. Mehdi Savaghebi, Associate Professor

Dr. Mohammad S. Golsorkhi, Assistant Professor

Dr. Navid Bayati, Assistant Professor

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- Brief description

Microgrids (MGs) are deemed as one of the main building-blocks of the future smart grids. It is expected that in a near future, smart grid emerges as a well-planned plug-and-play integration of MGs facilitating transition from top-down, central power systems to bottom-up distributed smart grids. However, incorporating power-electronic-based MG technologies into power systems can introduce several challenges. The main challenges consist of power quality (PQ), control and protection. Recently, various approaches have been developed to enhance the PQ of MGs as well as to appropriately protect the MGs. This tutorial aims at presenting advanced solutions to address the PQ and protection issues in MGs.

- Duration

Half a day

- Outline

- Control and Power Quality in Microgrids
(*Mehdi Savaghebi and Mohammad S. Golsorkhi – 3 hours*)
 - Control of distributed energy resources in MGs and renewable energy systems
 - Control of hybrid AC-DC microgrids
 - Virtual impedance and admittance for load sharing and PQ improvement
 - Secondary control for compensation of voltage unbalance and harmonics in microgrids
 - Coordinated control of voltage-controlled and current-controlled converters for PQ improvement
 - PQ in networked microgrids
- Protection of Microgrids
(*Navid Bayati – 1.5 hours*)
 - Protection challenges in AC and DC Microgrids
 - Protection of different microgrid configurations, clusters, shipboards, and aircrafts.
 - Application of conventional protection relays in microgrids
 - Fault detection and location techniques
 - Signal processing and deep learning-based protection methods

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-About the speakers



Mehdi Savaghebi has received the B.Sc. degree from University of Tehran, Iran, in 2004 and the M.Sc. and Ph.D. degrees with highest honors from Iran University of Science and Technology, Tehran, Iran in 2006 and 2012, respectively, all in Electrical Engineering. From 2014 to 2017, he was a Postdoc Fellow in the Department of Energy Technology, Aalborg University where he was an Associate Professor for 2017-2018. Currently, he is an Associate Professor and research team leader with Electrical Engineering Section, Department of Mechanical and Electrical Engineering, University of Southern Denmark, Odense, Denmark.

His main research interests include distributed generation systems, microgrids, power quality and protection of electrical systems. Dr. Savaghebi has been a Guest Editor of Special Issue on Power Quality in Smart Grids- IEEE Transactions on Smart Grid and Special Issue on Power Quality and Protection in Renewable Energy Systems and Microgrids- IET Renewable Power Generation. He is an Associate Editor of IEEE Access and a member of Technical Committee (TC) on Renewable Energy Systems and TC on Smart Grids, IEEE Industrial Electronics Society.



Mohammad S. Golsorkhi received the B.Sc. (Hons.) degree in electrical engineering from the Isfahan University of Technology, Isfahan, Iran, in 2009, the M.Sc. (Hons.) degree in electrical engineering from Tehran Poly Technique, Tehran, Iran, in 2012, and the Ph.D degree in electrical engineering from the University of Sydney, Sydney, Australia, in 2016. During 2015, he was a visiting Ph.D. student with the Department of Energy Technology, Aalborg University, Denmark. In 2016, he worked with the University of Hong Kong, Hong Kong, as a Postdoctoral Fellow. From 2017-2021, he was with the Department of Electrical and Computer Engineering, Isfahan University of Technology as an Assistant Professor.

Currently, he is an Assistant Professor at the University of Southern Denmark. His current research interests include control of microgrids, multi-microgrid systems, integration of renewable energy resources into distribution networks, and power electronics.



Navid Bayati was born in 1992. He received an M.Sc. degree in Electrical Engineering from Amirkabir University of Technology, Tehran, in 2017. Since 2019, he has been involved in research with Loughborough University, UK. He is graduated with a Ph.D. degree in Electrical Engineering (Power Systems) from the Department of Energy Technology, Aalborg University, Denmark, in November 2020. Then, he was involved as a Postdoctoral researcher at the University of Southern Denmark, since March 2021, on the protection of Microgrids by dSPACE and OPAL-RT. Currently, he is an Assistant Professor on power system protection at University of Southern Denmark.

His research interests are power system protection, DC/AC Microgrids, fault detection and location of renewable energy resource-based systems, stability of low-inertia systems, and protection of Microgrid clusters.

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- Relevant publications

- [1] M. Savaghebi, A. Jalilian, J. C. Vasquez, and J. M. Guerrero, “Secondary Control Scheme for Voltage Unbalance Compensation in an Islanded Droop-Controlled Microgrid”, IEEE Transactions on Smart Grid, vol. 3, no. 2, pp. 797-807, Jun. 2012.
- [2] M. Savaghebi, A. Jalilian, J. C. Vasquez, and J. M. Guerrero, “Secondary Control for Voltage Quality Enhancement in Microgrids”, IEEE Transactions on Smart Grid, vol. 3, no. 4, pp. 1893-1902, Dec. 2012.
- [3] M. Savaghebi, A. Jalilian, J. C. Vasquez, and J. M. Guerrero, “Autonomous Voltage Unbalance Compensation in an Islanded Droop-Controlled Microgrid”, IEEE Transactions on Industrial Electronics, vol. 60, no. 4, pp. 1390-1402, Apr. 2013.
- [4] M. M. Hashempour, M. Savaghebi, J. C. Vasquez, and J. M. Guerrero, “A Control Architecture to Coordinate Distributed Generators and Active Power filters Coexisting in a Microgrid”, IEEE Transactions on Smart Grid, vol. 7, no. 5, pp. 2325-2336, Sept. 2016.
- [5] M. S. Golsorkhi, M. Savaghebi, D. D. C. Lu, J. M. Guerrero and J. C. Vasquez, “A GPS- Based Control Framework for Accurate Current Sharing and Power Quality Improvement in Microgrids”, IEEE Transactions on Power Electronics, vol. 32, no. 7, pp. 5675-5687, Jul. 2017.
- [6] S. Y. Mousazadeh Mousavi, A. Jalilian, M. Savaghebi, and J. M. Guerrero, “Coordinated Control of Multifunctional Inverters for Voltage Support and Harmonic Compensation in a Grid-Connected Microgrid”, Electric Power System Research, vol. 155, pp. 254-264, Feb. 2018.
- [7] S. Y. Mousazadeh Mousavi, A. Jalilian, M. Savaghebi, and J. M. Guerrero, “Autonomous Control of Current- and Voltage-Controlled DG Interface Inverters for Reactive Power Sharing and Harmonics Compensation in Islanded Microgrids”, IEEE Transactions on Power Electronics, vol. 33, no. 11, pp. 9375-9386, Nov. 2018.
- [8] M. Baharizadeh, M. S. Golsorkhi, M. Shahparasti, and M. Savaghebi, “A Two-layer Control Scheme Based on P- \dot{V} Droop Characteristic for Accurate Power Sharing and Voltage Regulation in DC Microgrids”, IEEE Transactions on Smart Grid, vol. 12, no. 4, pp. 2776-2787, Jul. 2021.
- [9] M. S. Golsorkhi and M. Savaghebi, “A Decentralized Control Strategy Based on V-I Droop for Enhancing Dynamics of Autonomous Hybrid AC/DC Microgrids”, IEEE Transactions on Power Electronics, vol. 36, no. 8, pp. 9430-9440, Aug. 2021.
- [10] S. Beheshtaein, R. Cuzner, M. Savaghebi, S. Golestan, and J. M. Guerrero, “Fault Location in Microgrids: A Communication-based High-frequency Impedance Approach”, IET Generation, Transmission & Distribution, vol. 13, no. 8, April 2019.

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- [11] S. Beheshtaein, R. Cuzner, M. Forouzesh, M. Savaghebi, and J. M. Guerrero, “DC Microgrids Protection: A Comprehensive Review”, *Journal of Emerging and Selected Topics in Power Electronics*, Early Access, 2019.
- [12] S. Beheshtaein, R. Cuzner, M. Savaghebi, and J. M. Guerrero, “Review on Microgrids Protection”, *IET Generation, Transmission & Distribution*, vol. 13, no. 6, pp. 743-759, 2019.
- [13] S. Beheshtaein, M. Savaghebi, R. Cuzner, S. Golestan, and J. M. Guerrero, “Modified Secondary-Control Based Fault Current Limiter for Inverters”, *IEEE Transactions on Industrial Electronics*, vol. 66, no. 6, pp. 4798-4804, Jun. 2019.
- [14] F. Aminifar, S. Teimourzadeh, A. Shahsavari, M. Savaghebi, and M. S. Golsorkhi, “Machine Learning for Protection of Distribution Networks and Power-Electronic-Interfaced Systems”, *The Electricity Journal*, vol. 1, no. 34, Jan-Feb. 2021.
- [15] N. Bayati, E. Balouji, H. R. Baghaee, A. Hajizadeh, M. Soltani, Z. Lin, and M. Savaghebi, “Locating High-Impedance Faults in DC Microgrids Clusters Using Support Vector Machines”, *Applied Energy*, vol. 308, Dec. 2021.
- [16] N. Bayati, H. R. Baghaee, A. Hajizadeh, M. Soltani, Z. Lin, and M. Savaghebi, “Local Fault Location in Meshed DC Microgrids based on Parameter Estimation Technique”, *Early Access, IEEE Systems Journal*, Sept. 2021.
- [17] N. Bayati, H. R. Baghaee, M. Savaghebi, A. Hajizadeh, M. Soltani, and Z. Lin, “EMD/HT-based Local Fault Detection in DC Microgrid Clusters”, *Accepted for publication in IET Smart Grid*, Feb. 2022.