Control Architectures for Power Quality Enhancement in Microgrids

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Brief description:

Microgrids are deemed as one of the main building blocks of the future smart grids. Providing a high power quality for the customers is one of the main objectives in microgrids. On the other hand, the proliferation of different nonlinear and single-phase loads may result in power quality problems in microgrids such as voltage harmonic and unbalance. Since Distributed Generators (DGs) are often interfaced to the microgrid through a power-electronic converter, recently, some control approaches are proposed to control the interface converter aiming to compensate power quality problems.
This tutorial gives a summary and discussion about control schemes for power quality enhancement in microgrids. Coordinated control and sharing the effort of power quality problems compensation as two critical issues will be addressed. Furthermore, sharing of different components of load current among microgrid DG converters will be discussed. Hierarchical control scheme is considered as a proper way to integrate all the control objectives based on which the issues handled in different levels will be reviewed and discussed. Simulation and experimental results will be presented to support those methods.

Outline:

- ✓ Overview of power quality issues in microgrids (15 min)
- ✓ Introduction to virtual impedance concept (15min)
  - General control scheme for droop controlled microgrids
  - Virtual impedance control loop
- ✓ Virtual impedance for load sharing and power quality improvement in microgrids (30 min)
  - Virtual impedance for load sharing and distortion compensation
  - Adaptive virtual impedance
- ✓ Hierarchical control schemes for compensation of power quality problems (60 min)
  - Conventional compensation approaches
  - Primary, secondary and tertiary control for harmonic and unbalance compensation

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. Savaghebi, J. C. Vasquez, A. Jalilian, J. M. Guerrero, and T. L. Lee, "Selective Compensation of Voltage Harmonics in Grid-Connected Microgrids", *Elsevier Mathematics and Computers in Simulation (MATCOM)*, vol. 91, pp. 211-228, May 2013.

[5] L. Meng, F. Tang, M. Savaghebi, J. C. Vasquez, and J. M. Guerrero, "Tertiary Control of Voltage Unbalance Compensation for Optimal Power Quality in Islanded Microgrids", *IEEE Transactions on Energy Conversion*, vol. 29, no. 4, pp. 802-815, Dec. 2014.

[6] M. Savaghebi, Q. Shafiee, J. C. Vasquez, and J. M. Guerrero, "Adaptive Virtual Impedance Scheme for Selective Compensation of Voltage Unbalance and Harmonics in Microgrids", *IEEE PES General Meeting*, 26-30 Jul. 2015, Denver, USA.

[7] 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.

[8] 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*, Early Access, 2016.

[9] L. Meng, X. Zhao, F. Tang, M. Savaghebi, T. Dragicevic, J. C. Vasquez, and J. M. Guerrero, "Distributed Voltage Unbalance Compensation in Islanded Microgrids by Using Dynamic Consensus-Algorithm", *IEEE Transactions on Power Electronic*, vol. 31, no. 1, pp. 827-838, Jan. 2016.

[10] A. Mortezaei, M. G. Simoes, M. Savaghebi, J. M. Guerrero and A. Al Durra, "Cooperative Control of Multi-Master-Slave Islanded Microgrid with Power Quality Enhancement Based on Conservative Power Theory", *IEEE Transactions on Smart Grid*, Early Access, 2016.

Presenters' biography:

Mehdi Savaghebi (S'06-M'15-SM'15) 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 2007 to 2014, he was a Lecturer in Electrical Engineering Department, Karaj Branch, Azad University where he taught various courses and conducted research on power systems and electrical machines. In 2010, he was a Visiting Ph.D. Student with the Department of Energy Technology, Aalborg University, Aalborg, Denmark and with the Department of Automatic Control Systems and Computer Engineering, Technical University of Catalonia, Barcelona, Spain.

Currently, he is a Postdoctoral Fellow in Department of Energy Technology, Aalborg University. His main research interest is power quality issues in distributed generation systems and microgrids. Dr. Savaghebi is a member of Technical Committee of Renewable Energy Systems, IEEE Industrial Electronics Society and also IEEE Task Force on Microgrids Stability Analysis and Modelling.

Josep M. Guerrero (S'01-M'04-SM'08-F'15) received the B.S. degree in telecommunications engineering, the M.S. degree in electronics engineering, and the Ph.D. degree in power electronics from the Technical University of Catalonia, Barcelona, Spain, in 1997, 2000, and 2003, respectively. Since 2011, he has been a Full Professor at the Department of Energy Technology, Aalborg University, Aalborg, Denmark, where he is responsible for the Microgrid Research Program. His research interests include different microgrid aspects, including power electronics, distributed energy storage systems, hierarchical and cooperative control, energy management systems, and optimization of microgrids and islanded minigrids. Prof. Guerrero is an Associate Editor of the IEEE TRANSACTIONS ON POWER ELECTRONICS, the IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, and the IEEE INDUSTRIAL ELECTRONICS MAGAZINE, and an Editor of the IEEE TRANSACTIONS ON SMART GRID and the IEEE TRANSACTIONS ON ENERGY CONVERSION. He was the Chair of the Renewable Energy Systems Technical Committee of the IEEE Industrial Electronics Society. In 2014, he received the award of Highly Cited Researcher by Thomson Reuters