École Polytechnique Fédérale de Lausanne
Distributed Electrical Systems Laboratory
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Student project proposal

Project title
Control of Grid-Forming Converters for the Resynchronization of Islanded Microgrids

Project type ☒ MSc thesis ☐ BA semester project ☐ MSc semester project

Project responsible and e-mail
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Project description
One of the advantages of active distribution networks, such as microgrids, is their ability to operate both in grid-connected and islanded mode (i.e., after an intentional or unintentional disconnection from the bulk grid) [1]. The transitions from grid-connected to islanded mode and vice versa are called islanding and resynchronization manoeuvre, respectively. The latter requires a controller which adjusts voltage magnitude/phase and frequency of the microgrid at the point of connection to the bulk grid, such that the reconnection (i.e., the reclosing of the circuit breaker) does not cause large current transients [2]. This can be implemented in different ways. One option is to install a dedicated device at the point of connection which imposes the voltage to the downstream feeder [3]. Alternatively, one can modify the controllers of existing grid-forming converters, which may be located anywhere in the downstream feeder, and thereby indirectly manipulate the voltage at the point of connection [4]. For this purpose, one requires knowledge of the electrical grid, for instance the admittance matrix [5] and sensitivity coefficients [6]. The goal of this project is to develop such a resynchronization controller, implement it into an industrial embedded computer using LabVIEW, and experimentally validate it in the DESL microgrid laboratory.

Tasks of the student
- Formulation of the controller equations using the mathematical model of a generic grid.
- Implementation of the controller into an industrial embedded computer using LabVIEW.
- Experimental validation of the implemented controller in the DESL microgrid laboratory.

Requirements
- Solid knowledge of power systems (e.g., admittance matrix, power-low study).
- Basic knowledge of power electronics (e.g., voltage-source converters).
- Basic knowledge of control theory (e.g., proportional-integral-derivative controllers).
- Familiarity with the LabVIEW programming environment.
- Enthusiasm to work with real devices in microgrid the laboratory.

Literature
[1] CIGRÉ WG C6.11, "Development and Operation of Active Distribution Networks", CIGRÉ: Paris, FR, Tech. Rep. 457, 2011.
[2] L. E. Reyes Chamorro, "Real-Time Control Framework for Active Distribution Networks: Theoretical Definition and Experimental Validation", Ph.D. Thesis, EPFL: Lausanne, CH, 2016.
[3] J. Rocabert, G. M. S. Acevedo, A. Luna, J. M. Guerrero, J. I. Candela, and P. Rodriguez, "Intelligent Connection Agent for Three-Phase Grid Connected Microgrids", IEEE Trans. Power Electron., vol. 26, no. 10, pp. 2993-3005, 2011.

[4] J. Rocabert, A. Luna, F. Blaabjerg, and P. Rodriguez, "Control of Power Converters in AC Microgrids", IEEE Trans. Power Electron., vol. 27, no. 11, pp. 4734-4749, 2012.
[5] A. M. Kettner and M. Paolone, "On the Properties of the Compound Nodal Admittance Matrix of Polyphase Power Systems", IEEE Trans. Power Syst., vol. 34, no. 1, pp. 444-453, 2019.
[6] K. Christakou, J.-Y. Le Boudec, M. Paolone, and D.-C. Tomozei, "Efficient Computation of Sensitivity Coefficients of Node Voltages and Line Currents in Unbalanced Radial Electrical Distribution Networks", IEEE Trans. Smart Grid, vol. 4, no. 2, pp. 741-750, 2013.