Master project, 2020-2021

— Operating grid-forming control on medium-(low-)voltage networks —

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Context

Due to CO2 saving energy policies [1], the electricity production system has been moving towards a decentralized scheme, with more and more low-power production means distributed on the territory (wind or solar power plants). Among the technical challenges, there is that of ensuring stable power transfers between the new systems of production and the rest of power-grid. In particular, it must be considered for the modern power system that the stability problem is no longer the exclusive responsibility of a limited number of large power plants using high power synchronous rotating machines as generators. Now, any active-source or -load, connected to the grid with help of a Power-Electronics (PE) converter, has the ability to improve or damage overall stability of the grid [2]. In this context, H2020 European project MIGRATE [3] assessed the operating rules of an hypothetical 100% Power-Electronics grid. In this project, L2EP laboratory developed solutions (methods and tools) to manage the control of PE converters [4] along with respect of classical and new types of high-level control. Since MIGRATE project, L2EP Power-System team has been recognized as an international expert in Grid-Forming control theory, i.e. when PE converter is not only used to manage active or reactive power transfers but also to take part in the generation of the frequency-controlled-voltage [4]-[6].

Objective

Until now, Grid-Forming control theory has been explored at L2EP in the context of transmission-grid, assuming the specific conditions of a high voltage power-system. However, the evolution of the power-system goes in the direction of more and more energy production (or storage systems) at lower voltage levels, integrated to the distribution-grid. The operating conditions of the converter integrated to a transmission or a distribution grid are not the same: Typically, the grid lines impedances are different. Then, the connection inductive impedance between the converter and the grid can be drastically reduced in case of distribution applications (such as a bidirectional battery charger), by comparison with a transmission application for which the transformer and its leakage inductance is part of the production system. In short, the impedance seen by the converter is strongly different between the transmission or the distribution grids conditions and the control must be reworked accordingly.

The first objective of this master project is to evaluate the actual grid-forming control techniques performances under the specific conditions of a medium or low voltage distribution grid. Then, it is expected to propose improvement solutions, to be developed and tested in a Matlab-Simulink simulation environment.

Work steps

- Literature review on grid-forming control in distribution grid context
- Simulation model development of a simplified distribution grid
- Integration of Power-Electronics converter model + Control
- Grid-Forming robustness study and improvement solutions development

Keywords

Power-System, Power-Grid, Power-Electronics, Grid-Forming, Control-Design, Model-Based-Design, Matlab-Simulink

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