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Ph.D. DISSERTATION DEFENSE

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Title: The Efficient Control Schemes for Renewable Islanded Microgrid with Stability Proof

Chairperson: Dr. Lei Wu, Department of Electrical & Computer Engineering, School of Engineering and Science

Committee Members: Dr. Yi Guo, Department of Electrical & Computer Engineering, School of Engineering and Science
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ABSTRACT

Stimulated by government policy and technology development, a large fleet of distributed energy resources (DERs) has been installed on the demand side. Organizing the DERs to form islanded microgrids has been recognized to improve operating performance and system resiliency. However, due to the properties of high volatility, low inertia, and inadequate reserves for the DERs, the current islanded microgrid control schemes extended from the traditional hierarchical control of utility grids would react tardily and imprecisely. To this end, this thesis explores efficient control schemes for renewable islanded microgrids:

(i) A closed-loop design for the droop-based hierarchical control. By decomposing the calculation iteration of the slower control layers and enabling their compatibility with the faster control layers, the control processes in multiple layers are expected to continuously interact with each other and update together to improve the speed and accuracy of the control adjustment.
(ii) An asymmetric communication network for droop-free control. A direct communication graph is constructed to promote the spread of system disturbance toward one direction, which outperforms the undirected communication graph in system convergence speed and stability margin under the specific droop-free control structure.
(iii) A local power-sharing consensus for droop-free control. A local power-sharing scheme for droop-free control is proposed to contain disturbances within nearby nodes, which can reduce the number of nodes involved in the coordination and accelerate convergence performance.

These designs improve the control efficacy of islanded microgrids, and their stability properties are theoretically derived based on the steady-state analysis, eigenvalue analysis, Lyapunov method, and vulnerability analysis. Besides, Simulink and hardware-in-the-loop (HIL) testbeds are further built to compare the dynamics of the current and proposed control schemes, demonstrating that the proposed designs outperform the current control schemes in multiple aspects, such as control cost, settling time, system deviation, stability margin, etc.