ABSTRACT
A STUDY ON THE HIERARCHICAL CONTROL STRUCTURE OF THE ISLANDED MICROGRID

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Microgrid is essential in promoting the power system’s resilience by its ability to host small-scale DG units. Furthermore, the microgrid can isolate itself during main grid faults and supply its demands. However, islanded operation of the microgrid is challenging due to difficulties in frequency and voltage control. In islanded mode, grid-forming units collaborate to control the frequency and voltage. A hierarchical control structure, employing the droop control technique, provides these control objectives in three consecutive levels: primary, secondary, and tertiary. However, challenges associated with DG units in the vicinity of distribution networks limit the effectiveness of the islanded mode of operation.

In MV and LV distribution networks, the X/R ratio is low; hence, the frequency and voltage are related to the active and reactive power through line parameters. Therefore, frequency and voltage must be tuned for changes in active or reactive powers. Furthermore, the line parameters mismatch causes the voltage to be measured differently at each bus due to the different voltage drops in the lines. Hence, a trade-off between voltage regulation and reactive power sharing is formed, which causes either circulating currents for voltage mismatch or overloading for reactive power mismatch. Finally, the economic dispatch is usually implemented in tertiary control, which takes minutes to hours. Therefore, an estimation algorithm is required for load and renewable energy quantities forecasting. Hence, prediction errors may occur that affect the stability and optimality of the control.

This dissertation aims to improve the power system resilience by enhancing the operation of the islanded microgrid by addressing the abovementioned issues. Firstly, a linear relationship described by line parameters is used in droop control at the primary control level to accurately control the frequency and voltage based on measured active and reactive power. Secondly, optimization-based consensus secondary control is presented to manage the trade-off between voltage regulation and reactive power sharing in the inductive grid with highly line parameters mismatch. Thirdly, the economic dispatch-based secondary controller is implemented in secondary control to avoid prediction errors by depending on the measured active and reactive powers rather than the load and renewable energy generation estimation. The developed methods effectively resolve the frequency and voltage control issues in MATLAB/SIMULINK simulations.