

Power Swing Trajectory Influenced by Virtual Impedance-Based Current-Limiting Strategy

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Grid-forming (GFM) inverter-based resources (IBRs) can emulate the external characteristics of synchronous generators (SGs) through appropriate control loop design. However, in systems with GFM IBRs, the apparent impedance trajectory under current limitation differs significantly from that of SG-based systems due to the limited overcurrent capability of power electronic devices. This difference challenges the power swing detection functions of distance relays designed for SG-based systems. This paper presents a theoretical analysis of the apparent impedance trajectory over a full power swing cycle under two typical current-limiting strategies: variable virtual impedance (VI) and adaptive VI. The analysis reveals that the trajectory under VI current-limiting strategies differs significantly from that of a conventional SG. The results also indicate that the control parameters affect the characteristics of the trajectory. In addition, the new trajectories challenge conventional power swing detection functions, increasing the risk of malfunction. Furthermore, the implementation of VI leads to a deterioration in system stability. The theoretical analysis is further validated through simulations on the MATLAB/Simulink platform.