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Synchronous Compensators Considering Reactive Power for PLL Stability Improvement and Short-Circuit Ratio Evaluation

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Abstract-

This paper examines the impact of Synchronous Compensators (SC) on the stability of grid-following Inverter-Based Resources (IBRs), with a particular focus on the role of reactive power. Full-order simulation models of a commercial SC and a doubly-fed induction generator as the study model to represent the most complex IBR, are used. Using the short-circuit ratio (SCR) as the key index, the study confirms that the Phase-Locked Loop (PLL) in the IBR is crucial for system stability and shows that the reactive power injected by the SC plays a non-negligible role. It is shown that the main effect of the SC in the small-signal stability aspect is the Thévenin impedance seen by the PLL at the connection point, which, in the case of the SC, is the subtransient impedance and the SC reactive power. This idea is used to calculate the PLL eigenvalues movement easily. A new simple linear approximation model is proposed to estimate the correct SCR value for stability purposes considering the reactive power effect, as it is shown that the classical SCR measure does not fully capture the impact of the reactive power on the system stability.

Index Terms- Synchronous compensator, short-circuit ratio, reactive power, IBR stability, PLL stability.

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