

Abstract:

This thesis focuses on damping low-frequency power oscillations in renewable integrated uncertain power systems. The low-frequency power oscillations are associated with large interconnected power systems and can limit the power transfer capacity in the tie-lines and can also lead to rotor-angle instability. However, designing an inter-area oscillation damping controller is a complicated problem as it involves challenges such as modeling of large order renewable integrated power systems, variable operating conditions, network latencies in remote feedback signals, and actuation of control signals. In this aspect, the research work is divided into subtopics, with each focusing on these building blocks in a closed-loop control system.

The large order model of a renewable integrated power grid is addressed by proposing a new model order reduction methodology. In addition, measures are provided for ascertaining the validity of the obtained reduced order model under uncertainties. These results are obtained using the singular perturbation theory.

The variable operating conditions and complicated modeling are addressed by proposing adaptive damping controllers with input-output structure. Multiple adaptive controller designs are proposed, namely Model Reference Adaptive Control- Proportional Integral, Self-Tuning Control, Model-Free Adaptive Control, and Robust Model Reference Adaptive Controller.

The network latencies in the feedback signal are analyzed, and their impact on the performance of the adaptive controller is discussed. A new delay compensator is proposed, which has the advantage of compensating wide ranges of random delays. In addition, a new package drop compensator is proposed based on dynamic linearization.

The actuation of the damping control signals is analyzed by modulating the powers from the PV based power plant and by excitation system in the synchronous generator. It is observed that the PV based power plant can effectively produce damping control action, and a robust-adaptive control is used for achieving bounded actuation effort.

Rigorous case studies were carried out with the proposed methodologies and observed that significant advantages are achieved, especially under uncertainties.