

A Cyber Physical Framework for Remedial Action Schemes in Large Power Networks

Abstract

Despite the integration of advanced cyber technologies in monitoring and communication in electric power networks, design and development of control systems, and in particular, Remedial Action Schemes (RAS) tend to evolve at a very slow pace. The objective of this research is to study new distributed system modeling techniques to faithfully capture the physical and communication system characteristics as well as the "wave" like propagation of some disturbances. These new mathematical approaches lead us to propose new controls which seek to minimize the impact of disturbances.

As power networks are large-scale systems, both computationally and geographically, a centralized wide-area controller is practically difficult to implement. Therefore, our research is mainly focused on the design of distributed controllers for spatially interconnected cyber-physical systems. The idea is to adapt the distributed output feedback control method from network control theory to achieve high performance for an interconnected power system. We have developed a distributed control framework, which guarantees local and global stability of the interconnected subsystems, using a cyber-physical power system model where dynamics of each module is represented in terms of its local variables and the interconnection variables. Simulation results on different test systems validate the effectiveness of the proposed controller in improving the ability of the system to mitigate electromechanical disturbances.

To better explore the impact of power network topology on system stability, we expanded the existing partial differential equation (PDE)-based model for power system to capture both angle and voltage dependence to spatial parameters. The stability analysis of a continuum system for which robust methods have been developed provides an alternative to overcome the extreme difficulties associated with the stability analysis of a large dimensional discrete system. Considering powerful mathematical tools for PDEs, our objective is also to apply distributed control designs appropriate to the wave equation to our proposed continuum model and gain additional insight into mechanisms by which disturbance propagations in the power system can be mitigated.