Wide-Area Emergency Control in Power Transmission

This thesis concerns the development of new emergency control algorithms for electric power transmission systems. Diminishing global resources and climate concerns forces operators to change production away from fossil fuels and towards distributed renewable energy sources. Along with the change on production side measures must be taken on the demand side to maintain power balance. Due to these changes, the operating point of the power system will be less predictable. Traditionally, emergency controls are designed off-line by extensive simulations. The future power system is expected to fluctuate more, thus making the behaviour less predictable, suggesting the need for new intelligent wide-area emergency control algorithms. The fluctuating nature of the future power system calls for new methods of calculating remedial actions that are able to adapt to changing conditions. As part of this thesis convex relaxations are used to compute remedial actions when an emergency condition is detected, and the method is assessed using a set of benchmark systems. An optimal power flow approach is suggested to reconfigure a power system, and methods are introduced to be able to recover from an emergency condition and reach a secure stable equilibrium. In order to contain fast instability mechanisms, event-based emergency controls can be necessary, and this thesis also presents a contribution to real-time generation of event-based emergency control. By the use of contingency screening with post-contingency stability-margin information, system protection schemes are automatically generated and armed, and it is shown that, by examination of the physical phenomena behind the security threat, emergency controls can be properly allocated. Power systems can exhibit low-frequency oscillations due to the inertia of synchronous machines affecting each-other through electric power transfers. Today, dedicated controllers are applied to cope with such oscillations. However, faults can affect the behaviour of these controllers, or even separate them. The thesis presents a novel method that – without particular knowledge on existing controllers – reconfigures the close-loop system to guarantee stability in the case of faults. This is achieved through a stability-preserving reconfiguration design using absolute stability results for Lure type nonlinear power systems. It is implemented using a wide-area virtual actuator approach, and relies on the solution of a linear matrix inequality. The developed methods enables emergency control for real-time stabilization that adapts to changing conditions in the future power system. The results contribute to the development of a self-healing power system, where the power system automatically responds to system disturbances.

General information
Publication status: Published
Organisations: Department of Electrical Engineering, Automation and Control
Contributors: Pedersen, A. S.
Number of pages: 188
Publication date: 2015

Publication information
Place of publication: Lyngby
Publisher: Technical University of Denmark, Department of Electrical Engineering
Original language: English
Electronic versions:
Wide_Area_Emergency_Control.pdf
Source: PublicationPreSubmission
Source ID: 119519810