

A Study on Power System Stabilization by A Generator Control System Considering Multi-Machine Power Systems

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Long-distance transmission lines and complex interconnections are commonly employed in the transmission networks of current power systems to meet ever increasing demand in Japan. Such network configurations can cause the stability of a system to deteriorate.

The authors have developed the adaptive, multivariable optimal generator control systems that coordinate the excitation and governor control systems. They are based on Linear Quadratic Integral (LQI) control theory. They are confirmed to be effective for the improvement of power system stability compared with conventional excitation and governor control systems. However, it is impossible to design the system considering overall power system stability because it is usually designed using one machine infinite bus system model.

It is obviously very important to develop multi-machine power system stabilization techniques to cope with growing complexity and difficulty of power systems. The control scheme that coped with multi-machine power system stabilization techniques has been already developed. However, the schemes are based on a centralized control and it is not practical for actual large-scale power systems. A decentralized control scheme has been developed to solve this problem. The schemes use less communication among controllers than centralized control schemes. However, it may have a problem when the communication is lost.

This paper proposes a new control scheme for a decentralized generator control system without any communication. The overall power system is decomposed into separate subsystems. Each subsystem comprises one generator and relation among other generators. Interactions among subsystems are modeled as equivalent disturbance from other subsystems, and the order of the model is reduced using model reduction methods. The decentralized control is realized by applying a disturbance rejection control based on H_∞ control theory.

Two model reduction methods are applied to reduce the order of the multi-machine power system model. These methods are usually used in stability analysis of power systems. First one is the modal reduction method that allows to reduce the order of the

original model preserving the dynamic response of the target system. It is based on the eigenvalue analysis. The order reduction is realized by aggregation of similar modes and elimination of the inferior modes without affecting the frequency response of the original system significantly. Therefore, the reduced order model is expressed by a low order mathematical model with equivalent dynamic response of the original system and physical meaning of the original system is lost after the reduction. Second one is the conventional reduction method that allows to reduce the order of the original model preserving physical meaning of the original system. For example, some generators are reduced to one equivalent generator considering the original characteristic of the multi-machine response. Every parameter of the reduced model is calculated by short circuit current at certain reduction nodes of the original system.

The performance of the proposed scheme is evaluated by simulations using 5-machine and 16-machine power system models. Simulation results indicate that the proposed scheme improves overall power system stability and can outperform the conventional controls including LQI control.

The results of this paper can be summarized as follows:

- (i) The proposed control scheme can outperform current practical control schemes; the LQI control system designed using one machine infinite bus system model and the conventional control systems with PSS during transients.
- (ii) Under the same operating conditions, the proposed control scheme improves overall stability of the multi-machine power system than others.
- (iii) The proposed control schemes are confirmed to obtain almost the same performance compared with the control scheme that is designed without the model reduction.
- (iv) The performance of the proposed control scheme with the modal and the conventional reduction methods is almost similar. However, considering the salient feature of automatic reduction of the target system, the modal reduction method is more suitable for the proposed control scheme.