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Decentralized load frequency controller for a multi-area interconnected power system

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ABSTRACT

This paper proposes a control scheme for the load frequency control (LFC) problem of multi-area power systems. These systems are treated as interconnected dynamical systems. In the design of the proposed controller, each local area network is overlapped with states representing the interconnections with the other local area networks in the global system. Then, a decentralized control scheme is developed as function of the local area state variables and those resulting from the overlapped states which represent an approximation of the interconnection variables. The proposed controller guarantees the asymptotic stability of the overall closed loop system.

The simulation results indicate that the proposed control scheme works well. In addition, they show that the controlled system is robust to changes in the parameters of the power system and to bounded input disturbances acting on the system. Moreover, the simulation results show that the controlled system behaves well even when there is a maximum limit on the rate of change in power generation.

1. Introduction

Large-scale power systems are geographically distributed systems. They are composed of interconnected areas which are called subsystems. Each area has its own generator or group of generators, and it is responsible for its own load and scheduled power interchanges with neighboring areas. The connection between the areas is done using tie-lines or high voltage direct current (HVDC) links. Because the loading in a power system is never constant, it is necessary to design controllers which keep the system frequency and the inter-area tie-line power as near to the scheduled values as possible.

Load frequency control is an important control problem in the dynamical operation of interconnected power systems. The purpose of the load frequency controller is to keep the system frequency and the inter-area tie power as near as possible to the scheduled values during normal operation, and when the system is subject to disturbances or sudden changes in load demands. The input mechanical power to the generators is used to control the frequency of the output electrical power and to maintain the power exchange between the areas as scheduled. A well designed and operated power system should be able to cope with changes in the load and with system disturbances; and it should provide acceptably high level of power quality while maintaining both voltage and frequency within tolerable limits. The fundamental objectives of load frequency control are: (1) to maintain the system frequency at the nominal value, (2) to hold the interchange power among areas at scheduled value, and (3) to share the amount of required generation among generating units in a preset manner.

On the other hand, in order to design load frequency controllers to achieve high power quality standards, there is a need for data transmission over long distances. The transmission of such data is costly, and it induces errors; the probability of system disturbances are high. Such problem has been tackled by either (1) using decentralized stabilization without consideration of the performance of the overall system from an economical point of view, or (2) considering the system as if it is completely decentralized and designed local controllers which ignore the inter-actions between the multi-areas of the system. Clearly, such a practice leads to global sub-optimal systems.

The load frequency control problem has been investigated by many researchers. Kothari et al. [1] obtained an optimum integral and proportional integral (PI) controllers by using the concept of stability and techniques with conventional area control error (ACE). Velusami and Chidambaram [2] proposed a decentralized (PI) biassed dual mode controllers for two area interconnected thermal power system. Malik et al. [3] developed a generalized approach based on the concepts of discontinuous control, dual-mode control and variable structure systems. The proposed generalized approach was used to develop an LFC algorithm which was tested on a multi-area interconnected power system. Moon et al. [4] devised a proportional, integral and derivative (PID) control

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