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A fuzzy logic controlled superconducting magnetic energy storage, SMES frequency stabilizer

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ABSTRACT

This paper presents application of fuzzy logic controlled superconducting magnetic energy storage device, SMES to damp the frequency oscillations of interconnected two-area power systems due to load excursions. The system frequency oscillations appear due to load disturbance. To stabilize the system frequency oscillations, the active power can be controlled via superconducting magnetic energy storage device, SMES. The error in the area control and its rate of change is used as controller input signals to the proposed fuzzy logic controller. In order to judge the effect of the proposed fuzzy logic controlled SMES, a comparative study is made between its effect and the effect of the conventional proportional plus integral (PI) controlled SMES. The studied system consists of two-area (thermal–thermal) power system each one equipped with SMES unit. The time simulation results indicate the superiority of the proposed fuzzy logic controlled SMES over the conventional PI SMES in damping the system oscillations and reach quickly to zero frequency deviation. The system is modeled and solved by using *MATLAB* software.

1. Introduction

The main objective of using frequency stabilizer for the interconnected power systems is to fix the frequency in each area and keep the tie-line power flows in a permissible level [1,2]. It is well known that the superconducting magnetic energy storage SMES device has a very significant effect on diurnal load leveling, damping the turbogenerator subsynchronous resonance oscillations, improving the power system dynamic performance and protection of the distributed power systems [3–11]. For the frequency stabilizers purpose a high capacity superconducting magnetic capable of storing 10^7 to 10^8 MJ are necessary [12]. The previous studies prove that the area frequency deviation signal, and or the area control error ACE signal can be used as an input signal to the SMES controller. The response of using ACE as the control signal as compared with others has advantages of reducing the tie-line power deviations and also localize the contribution of the SMES units to the load disturbance in its own load area [6]. The conventional proportional plus integral (PI) controller can be used to control the SMES unit. But due to the nonlinearities on power systems, this control has limited performance due to its fixed parameters around a prescribed operating points. Recently, there are many control techniques such as robust, adaptive nonlinear neural network, fuzzy logic controllers have been suggested to overcome the problems of the conventional techniques to control the superconducting magnetic energy storage devices used for electric utility [7,13,14]. In this paper a fuzzy logic control technique is used to control the SMES unit to stabilize the frequency of the studied interconnected power system. The area control error ACE of each area is used as input signal to the fuzzy logic controller. The effect of the governor deadband is considered in this study. Different level of load disturbance in each area is considered to judge the ability of the proposed fuzzy logic controlled SMES frequency stabilizers. The performance of the proposed fuzzy logic controlled SMES frequency stabilizer is compared with that of the conventional proportional plus integral (PI) controller. The digital simulation results indicate the superiority of the proposed fuzzy logic controlled SMES over the conventional PI controlled SMES (Fig. 1).

2. Studied system model

The studied interconnected two-area power system is considered to be divided into two control areas that are connected by tie-lines. In each control area, all synchronous generators are assumed to form a coherent group. Each control area is equipped with SMES device. The studied interconnected two-area (thermal–thermal) power system, which is shown in Fig. 2 is given by the following set of the state variable differential equations [15].

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