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Improvement of Automatic Generation Control Behavior of Two Interconnected Areas Using SMES and TCSC

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ABSTRACT

In this paper, an attempt has been made to enhance the dynamic behaviour of Automatic Generation Control (AGC) of two areas two units using both Thyristor Controlled Series Compensator (TCSC) placed in the tie-line and Superconducting Magnetic Energy Storage (SMES) units are considered in both areas. For more realistic study, the effects of Governor Dead Band (GDB) and Generation Rate Constraints (GRCs) are taken into account for both areas. However, to conduct the system to better dynamic responses, we have implemented a PI-PD cascade controller. After that, a well-known and powerful optimisation algorithm named Firefly Algorithm (FA) is employed by evaluating the Integral of the Squared Error (ISE). From the obtained results, the implemented methods prove its efficiency from different view of points such as: minimisation of Overshoot and Undershoot Peaks (PO), (PU) and Settling Time (ST).

1. INTRODUCTION

At any moment, a power system operating condition should be stable, meeting various operational criteria, and it should also be protected in the presence of any emergency. Power system stability defined as the ability of the system to regain an acceptable state of equilibrium after being subjected to disturbances [1].

Nowadays, power systems have been operated closer to their stability limits due to economic and environmental constraints. Therefore, a stable and secure operation conditions present a very important challenge for the operators. Power system stability is mainly classified into three main categories as follows: rotor angle stability, frequency stability and voltage stability [2].

Frequency stability is defined as the ability of a power system to maintain a steady frequency within an acceptable range following a severe system disturbance resulting in a significant imbalance between generation and load [3].

For this reason, the Automatic Generation Control (*AGC*) has been introduced whose role is:

- to regulate the frequency to its specified nominal value;
- to maintain the interchange power between control areas at the scheduled values;
- to distribute the required change in generation among units to minimize the operating costs.

To attain these principal objectives, a linear equation called Area Control Error (ACE) has been used, which is associated with two main variables named as frequency deviation and tie-line power exchange. The ACE signal must be sets to zero in the case of any load variation in the system.

The AGC has been introduced with its four main actions (four control loops) as follows:

Primary Control Loop

Its main role is to re-establish a balance between generation and demand at frequency different from its nominal value.

Secondary Control Loop

This control also known as a Load Frequency Control (*LFC*) that allows to correcting the total power deviation.

Tertiary Control Loop

Typically, the operation of TCL which is the Economic Dispatch (ED), as a complementary to Secondary Control, is bound to the period of Scheduling but has in principle the same impact on the interconnected operation as SCL. The TCL is any automatic or manual change in the working points of generators (mainly by re-scheduling), to restore adequate Secondary Control Reserve (SCR) at the right time.

Load Scheduling

The Load Scheduling (LS) is the disconnection of loads from the synchronous electric system, usually performed automatically, to control the system frequency in emergency conditions.

The *LFC* problem in power systems has a long history. In a power system, *LFC* as an ancillary service acquires an important and fundamental role to maintain the electrical system reliability at an adequate level [4]. The *LFC* scheme has evolved over the past few decades and is used on interconnected power systems. There has been continuing interest in designing *LFC* with better performance to maintain the frequency and keep tie-line power flows within prespecified values using various control strategies [4].

For more realistic study, several non-linear constraints such as Governor Dead Band (*GDB*), Generation Rate constraint (*GRC*), Dynamic Boiler (*DB*), Time Delay (*TD*) have been introduced [5-8].

In control system design and analysis, certain design specifications are required to reduce the steady state error of the system [5].

The optimum value of controller parameters is obtained by minimizing a specified objective function [7].

Several control strategies have been suggested to address the load frequency control problem such as: classical,