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Enhanced Control Designs to Abate Frequency Oscillations in Compensated Power System

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Abstract: The interconnection of transmission, distribution, and generation lines has established a structure for the power system that is intricate. Uncertainties in the active power flow are caused by changes in load and a growing dependence on renewable energy sources. The study presented in this paper employs several controlling strategies to reduce frequency variations in series-compensated two-area power systems. Future power systems will require the incorporation of flexible AC transmission system (FACTS) devices, since the necessity for compensation in the power system is unavoidable. Therefore, a static synchronous series compensator (SSSC) is installed in both areas of our study to make it realistic and futuristic. This makes it easier to comprehend how series compensation works in a load–frequency model. With the integration of electrical vehicles (EVs) and solar photovoltaic (PV) systems, several control strategies are presented to reduce the frequency oscillations in this power system. Particle swarm optimization (PSO) is used to obtain the best PI control. To improve results, this work also covers the design of fuzzy logic control. In addition, the adoption of neural network control architecture is proposed for even better outcomes. The outcomes clearly show how well the proposed control techniques succeeded.

Keywords: load frequency control; flexible AC transmission; static synchronous series compensator; electric vehicles; solar PV; fuzzy logic control; neural network control

Citation: Yousuf, S.; Yousuf, V.; Gupta, N.; Alharbi, T.; Alrumayh, O. Enhanced Control Designs to Abate Frequency Oscillations in Compensated Power System. *Energies* **2023**, *16*, 2308. https://doi.org/10.3390/en16052308

Academic Editor: Akhtar Kalam

Received: 9 January 2023
Revised: 9 February 2023
Accepted: 15 February 2023
Published: 27 February 2023

1. Introduction

A power system is made up of many generating units that are linked together via tie lines to meet the load demand. Due to random changes in active and reactive power demand, the system frequency and tie-line power exchange vary. To maintain the stability and reliability of the power system, the change in frequency and tie-line power exchange need to be balanced quickly. Load Frequency Control (LFC) is the process of maintaining frequency and tie-line power in a state of balance. A power system is constantly subjected to some kind of disturbance, which causes power system components to trip. When subjected to disturbance, the power system is expected to settle down to some equilibrium. If the system's equilibrium is disturbed, the machine rotor will accelerate or decelerate in accordance with the laws of motion for rotating bodies [1].

In order to reduce frequency and voltage oscillations caused by load variations or abrupt changes in load requirements, automatic generation control (AGC) is crucial for the operation of electric power systems. Due to the increasing exploitation of renewable resources in the power system, the uncertainty in real power production has increased significantly. Additionally, load disturbances also disrupt the normal operation of a power