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Design of Optimal Model Predictive Controller for LFC of Nonlinear Multi-area Power System with Energy Storage Devices

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CONTENTS

Abstract—This paper proposes the bat-inspired algorithm (BIA) and gravitational search algorithm (GSA) as a new two artificial intelligence (AI) technique to design the model predictive controllers (MPC) with superconducting magnetic energy storage (SMES) and capacitive energy storage (CES) for load frequency control (LFC). In recent years, the designer used the trial, error technique and their expertise to set the parameters of the MPC with SMES and CES units. Herein, the BIA and GSA are used to tune the parameters of MPC with SMES and CES units simultaneously to overcome this problem. The proposed methods are applied to nonlinear interconnected three area power system to minimize the deviations of frequency and tie line powers against load perturbations. The superiority of the proposed methods is emphasized by comparing them with the BIA-based MPC without SMES and CES units and the conventional proportional-integral (PI) controller based on Ziegler-Nichols (ZN) technique.

Keywords: load frequency control (LFC), superconducting magnetic energy storage (SMES), capacitive energy storage (CES), model predictive control (MPC), bat inspired algorithm (BIA), gravitational search algorithm (GSA), Matlab/Simulink

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1. INTRODUCTION

In large-scale power systems, generating stations are typically connected by tie lines to exchange power among them. However, continuous load changes cause corresponding deviations in the system frequency and tie line powers [1]. These deviations in the system frequency and tie line power imply consequent changes in the generated power. In this regard, load frequency control (LFC) is utilized to retain both frequency and tie line power at their scheduled values during generation-load mismatches [2], [3]. Consequently, the frequency and tie line power deviations may persist for long time durations even when a system, with optimized supplementary controllers, undergoes a small load disturbance. Hence, active power supply with fast response is needed for fast compensation. Recently, superconducting magnetic energy storage (SMES) and capacitive energy storage (CES) units have been considered as effective countermeasures because they can inject