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Available Transfer Capability Calculation of Power Systems Using Opposition Selfish Herd Optimizer

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ABSTRACT

This article discusses the calculation and enhancement of available transfer capability (ATC) of different test systems with a unique condition. ATC is a strongly nonlinear AC optimal power-flow-based problem. In this article, biogeography-based optimization (BBO), grey wolf optimizer (GWO), selfish herd optimizer (SHO) and chaotic-selfish herd optimizer (CSHO) algorithm frameworks are implemented on different IEEE test systems, namely, IEEE 30-bus and IEEE 118-bus and Indian Northern Region Power Grid (NRPG) 246 bus systems under a variant condition to calculate ATC and enchantment of the ATC with and without unified power flow controller (UPFC) and contingency cases. The authors also propose to implement the concept of opposition-based learning (OBL), which is integrated with the SHO algorithm in this paper for improving the convergence characteristic and simulation study concerning the limitation of the conventional SHO algorithm. The effectiveness and feasibility of the proposed oppositional SHO (OSHO) algorithm are also tested with the help of the aforesaid test systems, and Friedman's test also has been performed.

KEYWORDS

Available transfer capability (ATC); Biogeography-based optimization (BBO); Chaotic-selfish herd optimizer (CSHO); Grey wolf optimizer (GWO); Friedman's test; Opposition-based learning (OBL); Optimum power flow (OPF); Selfish herd optimizer (SHO); Unified power flow controller (UPFC)

1. INTRODUCTION

In the present era, the modern power grid system is booming with rising economic, and simultaneously, some inter-regional power transfers have been enhancing at a much higher rate than transmission capacity which abbreviates system security and reliability. The available transfer capability (ATC) assessment is a tool to provide adequate information in advance on these type of transactions of power through the existing transmission line without violating the power system constraints [1–3]. The ATC is delimited, as per the North American Electric Reliability Council (NAERC), as the amount of the remaining transfer capability in the existing transmission system for the future transaction of electrical power keeping in mind the uncertainties and contingencies of power system [1]. According to the Federal Energy Regulatory Commission (FERC), the system operator must give ATC data in the publicly accessible open—access on an hourly and daily basis.

The ATC calculation is a real-time problem which adds an extra huddle to its evaluation process. There are a lot of financial and engineering benefits for real-time ATC evaluation as follows: firstly the on-line study can be boiled down to those cases relevant to actual operating circumstances. Secondly, if the ATC information is known, the operator can run the power system ten times or more power transaction conditions. Hence, more operating windows will be opened. Thirdly, the development and implementation of renewable energy and smart grid inject more uncertainties which make real-time ATC determination a hard nut to crack [2]. In early growths of ATC, estimation was dependant on the power flow of the network, hence, their computational speed was high. However, the modern large-scale power system consisting of the grid, distributed generators (DGs), etc. makes power flow equations complex and non-linear in nature. Therefore, to estimate accurate ATC by most of the linearized methods cannot be implemented easily, as, it involves voltage stability, thermal limit, reactive power generation limit and other power system constraints. Nowadays, several computational methods are being investigated to correctly estimate the ATC using the following concept:

- as a distributed state estimations process [4,5];
- with the concept of distributed control for distribution networks [6,7];
- with distributed contingency analysis method [8];
- conceding voltage stability monitoring [9,10];
- in view of optimal power flow (OPF) approach [11];

To achieve accurate estimation of ATC without violating power system constrains, BBO, GWO, SHO, CSHO and

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