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An investigation about the impact of the optimal reactive power dispatch solved by DE

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ABSTRACT

With the advent of new technology based on power electronics, power systems may attain better voltage profile. This implies the proposition of careful strategies to dispatch reactive power in order to take advantage of all reactive sources, depending on size, location, and availability. This paper proposes an optimal reactive power dispatch strategy taking care of the steady state voltage stability implications. Two power systems of the open publications are studied. Power flow analysis has been carried out, which are the initial conditions for Transient Stability (TS), Small Disturbance (SD), and Continuation Power Flow (CPF) studies. Steady state voltage stability analysis is used to verify the impact of the optimization strategy. To demonstrate the proposal, PV curves, eigenvalue analyses, and time domain simulations, are utilized.

1. Introduction

The problem of reactive power dispatch is generally bundled with the problem of maintaining load voltages within pre-specified limits. The generator voltage set-point values V_{Gi}^{ref} are optimized with respect to certain performance criteria subject to the reactive-power-balance constraints, the load voltage acceptable limits, the available limits on the generated reactive power, and the limits on voltage generators. The generation-based reactive power dispatch falls under the category of the optimal power flow (OPF).

Since transformer tap ratios and outputs of shunt capacitor/reactors have a discrete nature, while reactive power output generators, bus voltage magnitudes and angles are, on the other hand, continuous variables, the reactive power optimization problem is formulated as mixed-integer, nonlinear problem [1,2].

Algorithms based on the principles of natural evolution have been applied successfully to a set of numerical optimization problems. With a good degree of parallelism and stochastic characteristics, they are adequate for solving intricate optimization problems, such as those found in reactive optimization, distribution systems planning, expansion of transmission systems, and economic dispatch [3–9]. Publications present an extensive list of works concerning the application of evolutionary techniques to power systems issues [10,21,22]. In general, these applications concentrate primarily on power system planning, followed by distribution systems.

Lai and Ma [3] have presented a modified evolutionary strategy to solve the reactive power dispatch, obtaining good results. Other authors [5,6] have applied the same algorithm for other power system problems, reporting results using the IEEE30 system. A simplified evolution strategy has been used in [6] and compared with genetic algorithms, and the Lai and Ma algorithm. More recently, a proposal quite similar to [3] has been presented in [7]. In spite of these efforts, evolutionary techniques have not yet explored completely power system applications [11].

Differential Evolution (DE) algorithm has been considered a novel evolutionary computation technique used for optimization problems. The DE and some other evolutionary techniques exhibit attractive characteristics such as its simplicity, easy implementation, and quick convergence. Generally speaking, all population-based optimization algorithms, no exception for DE, suffer from long computational times because of their evolutionary/stochastic nature. This crucial drawback sometimes limits their application to off-line problems with little or no real-time constraints.

In these kind of algorithms, within an n-dimensional search space, a fixed number of vectors are randomly initialized, and then new populations are evolved over time to explore the search space and locate the optima. Differential Evolutionary strategy (DE) uses a greedy and less stochastic approach in problem solving. DE combines simple arithmetical operators with the classical operators of recombination, mutation and selection to evolve from a randomly generated starting population to a final solution. The fundamental

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