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TCPST allocation using optimal power flow and Genetic Algorithms

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ABSTRACT

This work presents an optimization model to allocate TCPST at congested transmission systems. The problem was resolved by the Genetic Algorithms (GA) together with an Optimal Power Flow (OPF). The proposed strategy used the GA to make the allocation of the TCPST and the OPF to obtain the load flow solution and optimal adjustments of the phase shifter's taps. The mathematical formulation of the methodology is based on installation's costs of the equipment and total system overload minimization. In order to diminish the search field a methodology to elect the most favorable substations to the devices allocation was considered. This methodology was tested at a 291 bus system that is equivalent, in heavy load, to the electric network of the State of Paraná in Brazil.

1. Introduction

The necessities of integration and interconnection of the transmission systems make the linked world-wide systems more complex. These necessities require deepened studies for the load flow optimization of the networks. Amongst the alternatives to improve the active load flow is the insertion of Flexible AC Transmission System (FACTS) at strategically points of the transmission system.

These devices are capable to control the impedance, voltage, current and phase angle of the transmission system, objectifying the management of the power flow, voltage profile, increase of the stability, correction of the power factor and loss minimization.

Amongst these objectives, the focus of this work is the controlling of power flows to manage congestions. In this case, one of the most applicable types of FACTS is the Thyristor Controlled Phase Shifting Transformer (TCPST) that adjusts the angular difference between the lines (modeled as an ideal phase shifter with null impedance inserted in series with the line, [1]).

In a general way, the impacts that the TCPST provoke in an electric network are in the direction to increase the production profits, diminish the load cut in order to take the system to the feasibility region, attenuate overload through the lines, control parallel flow, increase load capability of the system (that depends on the topology, distribution of loads and limits of the lines) and improve transitory stability.

Recently, social, financial, politics, geographical and ambient factors have hindered the construction of new transmission lines. Then, studies that make possible the installation of equipments to flexible and improve the capacity of the transmission network, as the TCPST, have vital importance.

However, the best choice for installation of these equipments is not a simple task due to the complexity of the electric system. So, one of the objectives of this work is to present a model to optimize the locations of them, in order to reduce the flows in heavily loaded lines.

Different techniques and studies have been used to resolve this problem.

According to Galiana et al. [2], the FACTS devices introduce new degrees of freedom into the operation of power systems because they liberate independent adjustments of some variables of the system which are not normally controllable, allowing the power flow and magnitude of the voltages control. They prove that the presence of FACTS increases the size of the security region.

Paterni et al. [3] use Genetic Algorithms (GA) to determine the best location of phase shifters in French network based on the cost factors of the device because this network had bottlenecks that imposed high cost of energy production.

Gerbex et al. [4,5] present searches algorithms to place FACTS devices in power systems using GA, Simulated Annealing (SA) and Tabu Search (TB). Basically, they allocate the devices selecting their localization and types as: Thyristor Controlled Series Capacitors (TCSC) that modifies the reactance of the lines; TCVR that controls the differences of voltage magnitudes between buses of the transmission line; TCPST, that controls the angular differences and Static Var Compensator (SVC) that injects or absorbs reactive power. The multi-objective function minimizes the overloads through the lines and the voltage deviation in relation of the implemented limits values. Analyzing the allocation of the individual types, it can be concluded that the TCSC and the TCPST are the most efficient to control the active power flow.

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