Behavior of Power System Equilibrium Points in Dynamic Available Transfer Capability Calculation

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Abstract

Available Transfer Capability (ATC) is of fundamental importance in electric power system planning and operation. The calculation of firm ATC in a power market environment is carried out based on day-ahead market dispatch with a set of security constraints. Incorporating dynamic security constraints into the ATC calculation not only renders a heavier burden on the computational approach, but also manifests complex system behavior in the neighborhood of its equilibrium points. This paper specifically highlights exotic system characteristics encountered during dynamic ATC calculation. The problem of ATC calculation is modeled as a nonlinear mathematical programming problem to maximize the power transfer subject to system technical and operating constraints. The dynamic ATC constraints are represented via the quadratic approximation of the stable manifold of the controlling unstable equilibrium point (UEP). A case study on the IEEE WECC 3- machine, 9-bus power system is presented and analyzed.

Keywords: *Available transfer capability (ATC), electric power system, equilibrium point, optimization.*

1. Introduction

Available Transfer Capability (ATC) is a crucial index in the competitive marketplace to quantify the unutilized extent of the transmission system to facilitate additional energy trading [1], [2]. ATC determination should include adequate uncertainties existing in the physical system structure such as load fluctuations and equipment availabilities. The latter can be accounted for by analyzing a credible set of system contingencies [3]. Independent systems operators (ISOs) calculate ATC on hourly basis and post its values online to reflect market conditions as the market timeline progresses from day-ahead through real-time [4]. ATC can also be calculated two days to few months in advance of the dispatch day, as with the current practices of the New York ISO [5].

Various approaches addressed the issue of ATC computations based on static security considerations [6]–[10]. Nonetheless, the task of calculating the ATC subject to dynamic security constraints remains far more challenging with fewer approaches available [11]. This is due to the fact that stressed power systems exhibit complex dynamic behaviour [12]. Furthermore, dynamic ATC calculation algorithms are based on mature technologies commonly used in transient stability studies. The environment at which the ATC is required to be calculated is different from traditional stability studies. This new environment is typically characterized by multiple energy transactions, market schedules and processes, as well as increased uncertainties due to the proliferation of variable

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