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Coordinated preventive control of transient stability with multi-contingency in power systems using trajectory sensitivities

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ABSTRACT

In this paper, the challenging multi-contingency transient stability constrained optimal power flow problem is partitioned into two sub-problems, namely optimal power flow (OPF) and transient stability control, solved in turn with conventional well trusted power system analysis tools instead of tackling it directly using a complicated integrated approach. Preventive multi-contingency transient stability control is carried out with generation rescheduling based on trajectory sensitivities using results obtained from a conventional transient stability simulation. A new iterative approach is proposed to optimally redistribute the generation from the critical machines to noncritical machines with the help of conventional OPF. Results on the New England 10-machine 39-bus systems demonstrate that the proposed method is capable of handling multiple contingencies and complex power system models effectively with solution quantity and time comparable with conventional integrated approaches.

1. Introduction

Transient stability is one of the major threatens for power system operation. With increasing economical pressure and intensified transactions, especially in competitive environment, to maintain transient stability of the economic operation to an acceptable level becomes more important. Preventive control or remedial actions for transient stability enhancement should be taken if credible dangers of instability are detected. Security dispatch is to provide economic operation in the presence of a specific list of contingencies, which becomes more complicated when transient stability concerns are taken into account [1]. In this paper, a new methodology for transient stability dispatch is introduced to reconcile the possible conflict between economy and transient stability simultaneously in an optimal operating point.

Basic formulation for transient stability dispatch is presented preliminarily in [2]. The usual cost function is augmented by including transient stability indices across selected cutsets. A trade-off between optimal economy and steady-state and transient stability is obtained by optimization. Similarly, in [3], instability index is defined with potential energy and algebraic interpretations. Insecurity cost is assigned together with the total system cost. After that, optimal dispatch is taken for real power scheduling.

Generation rescheduling has long been recognized as an effective means to alleviate power system insecurity. For several decades, many efforts, for example, in [4–11], have been made for dynamic security dispatch via preventive control and generation rescheduling. In [4–6], sensitivities of the energy margin to system parameters, such as generation output, are proposed for generation rescheduling. In [4], sensitivity with respect to generation power is studied based on extended equal area criterion and a related transient stability margin. Economic dispatch algorithm is remarked to be extended to transient stability dispatch. In [5], generation rescheduling is carried out by the combination between transient stability constraints and optimization techniques based on the sensitivities of the energy margin. In [6], preventive generation rescheduling is taken based on a structure preserving energy margin sensitivity-based analysis to stabilize a transiently unstable power system. In [7,8], trajectory sensitivities are calculated to provide a preventive rescheduling scheme. In [7], the sensitivity trajectory of the most critical rotor angle, defined as a good coherent index, with respect to the generation outputs is addressed to determine the rescheduling. In [8], optimal dynamic security constrained rescheduling is resolved by introducing power constraints for transient stability, which is produced based on trajectory sensitivities for credible contingencies.

Unlike sensitivity methods, in [9], transient stability dispatch is accomplished by the improvement of the coherence of machines according to the variation rate of generator speeds at fault clearing time. Optimization should be taken into account for the ultimate rescheduling. In [10], generation rescheduling is realized via shifting generation from critical machines to noncritical machines, the amount of which depends on the size of stability

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