TRANSIENT STABILITY-CONSTRAINED OPTIMAL POWER FLOW

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Abstract - This paper proposes a new approach able to maximize the interface flow limits in power systems and to find a new operating state that is secure with respect to both, dynamic (transient stability) and static security constraints. It combines the Maximum Allowable Transfer (MAT) method, recently developed for the simultaneous control of a set of contingencies, and an Optimal Power Flow (OPF) method for maximizing the interface power flow. The approach and its performances are illustrated by means of simulations carried out on a real world power system.

Keywords: On-line transient stability assessment and control; real time preventive control; dynamic security constrained optimal power flow; SIME; available transfer capability.

1. SUMMARY

Nowadays, the on-line determination of the system stability limits is necessary because some scenarios encountered in real time operation cannot be anticipated. The need for this on-line analysis has also been increased because some power systems are being operated in more stressed conditions, as a consequence of the environmental and/or economical restrictions for building new electric facilities near load centers, and the deregulation process that is being applied to permit independent power producers to sale electric energy [1,2,3].

In the past, some authors have proposed techniques for solving this very challenging problem [4, 5]. Other authors have tried to find a more comprehensive solution that combines security and economy, by coupling a transient stability assessment program with an Optimal Power Flow (OPF) program [6 to 9]. This paper describes an efficient method that maximizes interface power limits and finds a new power system operating state that is secure with respect to transient stability and static constraints. This approach combines the Maximum Allowable Transfer (MAT) method and an OPF program [10, 11]. The MAT method [12] is an efficient iterative on-line process that has been recently developed for maximizing the interface power flow transfer limits. This method is shown to be compatible with requirements for real-time preventive monitoring and control, and is able to encounter stringent needs of the present competitive generation market.

It relies on the Single Machine Equivalent (SIME) method [13, 14] for identifying, from a very large list of contingencies, the set of dangerous ones, finding the critical machines on which a preventive control action (generation rescheduling) should be applied for stabilizing the system, and computing the amount of the active power change that should be performed on each critical generator. Figure 1 shows the time-domain trajectories of the multimachine system and the corresponding One Machine Infinite Bus (OMIB) equivalent.

After obtaining these useful data from SIME, the MAT method computes a control action that should be applied to the critical generators in order to stabilize the whole set of dangerous contingencies simultaneously. Once the control actions are applied, a generation rescheduling and a power flow are performed, a new operating state is obtained, and another iteration of the MAT method is carried out for verifying that the new system operating state is stable for the set of critical contingencies. If the system is stable for all the contingencies, a new power flow limit has been found; if this is not the case, the MAT method computes a new preventive control action, and so on. In general, three to four iterations are sufficient to converge to the solution.

In this paper, the MAT method is improved by adding an OPF function to perform the generation rescheduling. The OPF objective function is set to maximize the interface power flow in some selected tie lines, while respecting, at the same time, the values given by the MAT method and the bus voltage and power line limits. In this way, the new power flow transfer limit obtained by the MAT method is secure with respect to both, the dynamic and the static security constraints.

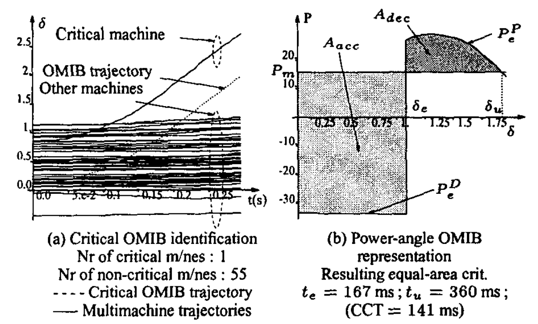

Figure 1. Time-domain machines' and OMIB's trajectories; resulting equal-area criterion. A real-world case

This coupling of the MAT method and the OPF program is tested using a model of the South-Southeast Brazilian power system with 16 areas, 1185 buses, 1391 lines, 599 transformers and 56 machines; the voltage levels range from 138 to 765 kV. The initial base case was established in 1995 and corresponds to a heavy load scenario of 33,299 MW forecasted for 1998.