

## Optimal Placement of the Unified Power Controller to Improve the Power System Restoration

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**Abstract :** One of the most important parts of the restoration process of a power network is the synchronizing of its subsystems. In this situation, the biggest concern of the system operators will be the reduction of the standing phase angle (SPA) between the endpoints of the two islands. In this regard, the system operators perform various actions and maneuvers so that the synchronization operation of the subsystems is successfully carried out and the system finally reaches acceptable stability. The most common of these actions include load control, generation control and, in some cases, changing the network topology. Although these maneuvers are simple and common, due to the weak network and extreme load changes, the restoration will be associated with low speed. One of the best ways to control the SPA is to use FACTS devices. By applying a soft control signal, these tools can reduce the SPA between two subsystems with more speed and accuracy, and the synchronization process can be done in less time. Meanwhile, the unified power controller (UPFC), a series-parallel compensator device with the change of transmission line power and proper adjustment of the phase angle, will be the proposed option in order to realize the subject of this research. Therefore, with the optimal placement of UPFC in a power system, in addition to improving the normal conditions of the system, it is expected to be effective in reducing the SPA during power system restoration. Therefore, the presented paper provides an optimal structure to coordinate the three problems of improving the division of subsystems, reducing the SPA and optimal power flow with the aim of determining the optimal location of UPFC and optimal subsystems. The proposed objective functions in this paper include maximizing the quality of the subsystems, reducing the SPA at the endpoints of the subsystems, and reducing the losses of the power system. Since there will be a possibility of creating contradictions in the simultaneous optimization of the proposed objective functions, the structure of the proposed optimization problem is introduced as a non-linear multi-objective problem, and the Pareto optimization method is used to solve it. The innovative technique proposed to implement the optimization process of the mentioned problem is an optimization algorithm called the water cycle (WCA). To evaluate the proposed method, the IEEE 39 bus power system will be used.

**Keywords :** UPFC, SPA, water cycle algorithm, multi-objective problem, pareto

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