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Determination of load shedding to provide voltage stability

Xu Fu [a,b,*], Xifan Wang [a]

[a] Department of Electrical Engineering, University of Xi'an Jiao Tong, Shaanxi, Xi'an 710049, China
[b] Department of Power System Planning, Northwest Electric Power Design Institute, Shaanxi, Xi'an 710075, China

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ABSTRACT

A computationally simple algorithm is developed for studying the load shedding problem in emergencies where an ac power flow solution cannot be found for the stressed system. The proposed algorithm is divided into two sub-problems: restoring solvability sub-problem and improving voltage stability margin (VSM) sub-problem. Linear optimization (LP)-based optimal power flow (OPF) is applied to solve each sub-problem. In restoring solvability sub-problem, rather than taking restoring power flow solvability as direct objective function, the objective function of maximization of voltage magnitudes of weak buses is employed. In VSM sub-problem, the traditional load shedding objective is extended to incorporate both technical and economic effects of load shedding and the linearized VSM constraint was added into the LP-based OPF. Case studies with a real 682 bus system are presented. The simulation results show that the proposed load shedding algorithm is effective, fast in finding the load shedding scheme to solve the problem of restoring solvability and improving VSM.

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1. Introduction

Deregulation has significantly changed the functioning of the power systems of today. However, the system security is still the most important aspect of the power system operation and cannot be compromised in a market-driven approach. A number of methods, both technical and economic, dealing with transmission congestion in deregulated electricity markets, have been proposed in the literature [1–4]. Recently, owing to the continuous growing on system interconnections and demand for electricity, power systems worldwide are operating ever closer to their transfer capability limits, and voltage stability has become a major concern in power systems operation. Thus it is important for system operators to be aware of and control the distance between actual point and that of collapse. Massive research work can be found in literature to improve voltage stability margin (VSM) [5–10]. Voltage instability is generally triggered by either of two types of system disturbances: component outage and load increase. Since outage of a heavily loaded transmission line or tripping of a large generating unit may lead the system to collapse (power flow becomes unsolvable) immediately, it is very important to maintain power flow solvability when unsolvable cases occur. Load shedding can prevent a system blackout in these situations. However, due to economical reasons, it is very important to define a methodology capable of indicating an optimal load shedding scheme minimizing the financial losses.

This paper presents a framework for determining a load shedding strategy for the restoration of power flow solvability and improvement of VSM. The proposed algorithm is divided into two sub-problems: restoring solvability sub-problem and improving VSM sub-problem. In each sub-problem, an LP-based OPF is used. The main reasons for decomposing the overall problem into two sub-problems are as following:

(1) The decomposition of the overall problem into different sub-problems minimizes the risk of failure in obtaining the solution.
(2) The control algorithm calculated using single step optimization method does not give the reasons that lead to unfeasible operation (no converged ac power flow solutions) or insufficient VSM.

This paper is organized as follows: Section 2 describes the basic framework. Section 3 describes the proposed load shedding strategy for restoring solvability. Section 4 describes the load shedding for improving VSM. Section 5 presents the numerical results, and Section 6 concludes the paper.

2. Framework for proposed load shedding scheme

This section describes the overall solution procedure of the proposed load shedding scheme. In this procedure, the load shedding strategy is divided into two sub-problems: restoring solvability sub-problem and improving VSM sub-problem.

* Corresponding author at: Department of Power System Planning, Northwest Electric Power Design Institute, Shaanxi, Xi'an 710075, China.
E-mail address: fuxumail@gmail.com (X. Fu).

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