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Reactive power rescheduling with generator ranking for voltage stability improvement

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ABSTRACT

In a power system, voltage stability margin improvement can be done by regulating generators voltages, transformers tap settings and capacitors/reactors rated reactive powers (susceptances). In this paper, one of these methods, which we name "reactive power rescheduling with generator ranking", is considered. In this method, using "ranking coefficients", the generators are divided into "important" and "less-important" ones and then, voltage stability margin is improved by increasing and decreasing reactive power generation at the important and less-important generators, respectively. These ranking coefficients are obtained using "modal analysis". In this paper, the method's performance for two types of ranking coefficients has been analyzed. Also, for comparison purpose, the "usual form of optimal reactive power dispatch" method has been simulated. For all simulations, the IEEE 30 bus test system has been used. The simulation results show that in the former method, for either type of ranking coefficients, voltage stability margin is considerably improved and, usually, the system active loss and the system operating cost are increased. Also, in the latter method, voltage stability margin is improved and the system active loss and the system operating cost are decreased.

1. Introduction

The transfer of power through a transmission network is accompanied by voltage drops between the generation and consumption points. In normal operating conditions, these drops are in the order of a few percents of the nominal voltage. One of the tasks of power system planners and operators is to check that under heavy stress conditions and/or following credible events, all bus voltages remain within acceptable bounds. In some circumstances, however, in the seconds or minutes following a disturbance, voltages may experience large and progressive falls, which are so pronounced that the system integrity is endangered and power cannot be delivered correctly to customers. This catastrophe is referred to as voltage instability and its calamitous result as voltage collapse. This instability stems from the attempt of load dynamics – especially loads supplied with under load tap changing transformers (ULTC), induction motors and thermostatic loads – to restore power consumption beyond the amount that can be provided by the combined transmission and generation system [1]. Nowadays, there are some voltage stability criteria being implemented. For example, the Western Electricity Coordinating Council (WECC) proposes a minimum voltage stability margin (VSM) requirement of 5% considering simple contingencies, 2.5% for double contingencies, and larger than zero for multiple contingencies. In a similar way, the ONS (Brazilian System Operator) has also initiated some studies and recommends a minimum VSM requirement of 6% also considering simple contingencies. Both criteria are based on VSM index, which is obtained from PV curve computations and represents the distance from the current operating point to the voltage stability limit [2].

"Reactive power management" is the general name of methods which try to improve voltage profile/stability by regulating generators voltages, transformers tap settings, reactive sources settings and installing new reactive sources. These methods can be divided into two areas: reactive planning (allocation) and reactive dispatch (re-dispatch, scheduling, rescheduling). Also, the dispatch area can be divided into two areas: off-line reactive dispatch and on-line reactive dispatch. In the reactive planning area, the period of study is the next few months or the next few years and installing the new reactive sources are also considered. In the off-line reactive dispatch area, only installed reactive sources are used and the period of study is the next few days or the next few hours. In the on-line reactive dispatch area, only installed reactive sources are used and the period of study is the next few minutes or the next few seconds [3].

In the off-line reactive dispatch area, voltage profile/stability improvement is done by regulating generators voltages, transformers tap settings and capacitors/reactors rated reactive powers (susceptances). For this purpose, usually two groups of methods are used. In the first group methods – which are referred by names such as "optimal reactive power dispatch", "reactive power optimization", etc. – a specific optimization problem with specific

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