Electric Power Systems Research 80 (2010) 436–443

Contents lists available at ScienceDirect

Electric Power Systems Research

journal homepage: www.elsevier.com/locate/epsr

Preventive voltage control actions to securely face load evolution in power systems

A. Marano Marcolini*, J.L. Martínez Ramos, E. Romero Ramos, A.L. Trigo García

Department of Electrical Engineering, University of Seville, Camino de los Descubrimientos s/n, 41092 Sevilla, Spain

ARTICLE INFO

Article history:
Received 19 September 2008
Received in revised form 23 April 2009
Accepted 7 October 2009
Available online 13 November 2009

Keywords:
Reactive power control
System Operation
Optimization
Sensitivity analysis
Voltage stability

ABSTRACT

One of the main aims of the System Operator (SO) is to maintain in every moment the system parameters between feasible operational margins. In certain periods of the day the load suffers fast changes which cause, specially when it tends to increase, a generalized voltage decrement and a more stressed condition for many reactive resources. In such cases, many devices may arrive to their operational limits, situation which translates into a weaker system. To avoid this negative effect the control variables should be rescheduled to maintain the normal operation conditions in the foreseeable future. This work proposes a useful tool to assist the SO when determining such actions. The main improvements are due to the implementation of a hybrid method that allows the comparison of different kinds of control variables and the inclusion of the operator background and experience in the algorithm that determines the actions. The performance of the proposed method is tested in both the IEEE 14-Bus and 118-Bus test systems.

1. Introduction

Voltage control in an electric system is one of the most critical tasks for the System Operator (SO), especially when market liberalization as well as the increment in demand cause the system to work under heavy load conditions, usually close to its working limits. Consequently, it is important for the operator to have at his disposal as much information and assistance as possible. This assistance should be useful to take the pertinent decisions in normal system operation [1,2].

This paper presents a method that focus on the assistance needed by the SO in normal operation state providing important information about the evolution of the system when the load varies and determining a reduced number of control actions to improve that system evolution. The main objective is to enlarge the system feasible operational region when working with the future load conditions. The proposed approach consists in avoiding, as far as possible, the limits on the reactive devices by redistributing the reactive generation effort among the available facilities. By doing so, the system becomes more flexible and the new working point will be further away from the operational limits. One of the main improvements presented is the inclusion of a hybrid method that allows the comparison of different kinds of control actions ranking them according to their efficiency in reaching the proposed objective.

The reactive control variables ($\boldsymbol{u}$) at the disposal of the SO considered in this work are the voltages of the PV buses, V_g, LTC transformers, t, and capacitor or reactor banks, (b_{sh}). Units' additional active power rescheduling and load shedding are active power control actions used to prevent voltage collapse when the system is close to this critical point. As this work is aimed to study the system evolution in normal situation such actions will not be considered, even if the method could be easily extended to include them.

The method can be easily applied to take into account the most probable and critical contingencies which may happen in each scenario. This can be done just by releasing the line or generator considered in the contingency and executing the method with the resulting system state. The SO can study in such a way several scenarios, getting valuable information about the most pertinent preventive actions in different cases.

For a particular operating point and following a specific pattern of load increment, the amount of additional load that would cause an infeasible working point is called the loading margin. There are several techniques to determine the loading margin caused by a voltage collapse [3,4].

Continuation methods [5–8] are based on the power flow equations of the system, looking for the load that leads the system out of its feasible operational region. The method consists in following the solution path from a base case to a loadability limit, taking into account that the path folds at the limit point. Another possibility is

* Corresponding author. Tel.: +34 954481281; fax: +34 954487284.
E-mail addresses: alejandromm@us.es (A. Marano Marcolini), jlmr@esi.us.es (J.L. Martínez Ramos), eromero@us.es (E. Romero Ramos), trigoal@us.es (A.L. Trigo García).

0378-7796/$ – see front matter
doi:10.1016/j.epsr.2009.10.006