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Improving static techniques for the analysis of voltage stability

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ABSTRACT

The currently available dynamic techniques for the analysis of voltage stability are truly accurate but also expensive in terms of computation time. With the objective of overcoming such a disadvantage, several static techniques have been developed. Unlike conventional dynamic techniques, they share the advantage of drastically reducing computation time. However, they have disadvantages as well since they can not achieve results as accurately as conventional dynamic techniques do, fact admitted by the great majority of their authors. Another disadvantage is that since they are static techniques and therefore no time is involved, they can not control the chronological sequence of post-disturbance events. That is, if the power system succeeds in remaining stable after disturbance, then different time delay control devices can activate. What is more, any of these devices can stimulate the action of others producing in consequence a chain of post-disturbance events, which must not be ignored. A static technique for the analysis of voltage stability is proposed in the present paper. This technique shows higher accuracy in comparison with those currently available while keeping a reduced computation time. For this to be possible, modifications on the conventional Power Flow study are carried out, which includes a detailed modeling of the devices that are part of the power systems and a control of the chronological sequence of post-disturbance events through different time delay control devices.

1. Introduction

All over recent years, voltage stability has become one of the most important concerns of power systems around the world. The IEEE/CIGRE Joint Task Force on Stability Terms and Definitions, on the 2004 year, said [1] "*As power systems have evolved through continuing growth in interconnections, use of new technologies and controls, and the increased operation in highly stressed conditions, different forms of system instability have emerged. In this way, voltage stability, frequency stability and inter-area oscillations, among others, have become greater concerns than in the past*". This new standing of voltage stability launched new research lines for a better understanding of not only physical aspects but also efficiency of calculation techniques. Most dynamic techniques for stability analysis are truly effective since they yield accurate results but also, they are expensive in terms of computation time, especially for long term phenomena such as voltage stability.

With the objective of overcoming such a disadvantage, different static techniques like V–Q curves [2–5], modal Analysis [6–9], continuation methods [10], singular values decomposition [11,12] and some others were developed and presented in [13–17]. These techniques offer an advantageous drastic reduction in computation time. In addition, some of them allow obtaining relative indexes which in turn facilitates an integral sight of the problem. However, they have disadvantages as well. One of them, admitted by almost all their authors, is that they may yield erroneous results due to the fact that they can not control the chronological sequence of post-disturbance events since they are static techniques and therefore no time is involved. That is, after disturbance, if the system succeeds in remaining stable, then different time delay control devices can activate. In addition, any of them can stimulate others producing a sequence of chained post-disturbance events. If such chained events are not controlled, then the technique may lead to erroneous results.

There is also a simplified dynamic technique called Quasi Steady State (QSS) approach [18–20] that allows replacing transient differential equations by equilibrium equations. Therefore, long term variables during the transient period can be considered constant, which considerably reduces computation time. This technique is similar to the static technique proposed and developed in this paper but it is still a dynamic technique with all the advantages and disadvantages that characterized them.

The present paper proposes a new static technique for the analysis of Voltage Stability (VS). This technique shows higher accuracy

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