Electrical Power and Energy Systems 33 (2011) 531–539

Contents lists available at ScienceDirect

Electrical Power and Energy Systems

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

Improvement of transient stability of power systems with STATCOM-controller using trajectory sensitivity

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ARTICLE INFO

Article history:
Received 7 December 2006
Accepted 6 December 2010
Available online 6 January 2011

Keywords:
Trajectory sensitivity analysis
Transient stability margin
STATCOM

ABSTRACT

This paper discusses the use of trajectory sensitivity analysis (TSA) in determining the transient stability margin of a power system compensated by a shunt FACTS device. The shunt device used is static synchronous compensator (STATCOM). It is shown that TSA can be used for the design of controller for the STATCOM. The preferable locations for the placement of the STATCOM for different fault conditions are also identified. The effects of STATCOM in maintaining different bus voltages in the post-fault condition are studied. The STATCOM is modeled by a voltage source connected to the system through a transformer. The systems used for the study are the WSCC 3-machine 9-bus system and the IEEE 16-machine 68-bus system.

1. Introduction

The use of FACTS devices at strategic locations with well-designed controllers can help in improving the operational efficiency of power systems. This is very important in view of the increasing competition in electric energy industry caused by the undergoing restructuring and deregulation in different parts of the world. With the increasing demand for electrical power in one hand and environmental and economic constraints on building of new power generation and transmission infrastructure on the other, more efficient utilization of the existing system has become important. FACTS controllers can be useful tools to meet that requirement. As systems are pushed to their limits, maintaining stability becomes more difficult. This requires improved tools for assessing available stability margins of a system. Trajectory sensitivity analysis (TSA) can be a viable option for the stability assessment in power systems.

Transient energy function (TEF) method is a tool used for transient stability assessment. But this becomes increasingly complex when detailed models are considered and FACTS devices along with controllers are included in the system. The computation of controlling unstable equilibrium point (UEP) may pose increased computational problems. The use of TSA as an alternative to avoid this problem has been pointed out in [1]. The use of trajectory sensitivity (TS) in finding critical values of parameters and dynamic rescheduling of generation has been discussed in [2]. The technique to extend the method for systems with both continuous and discrete equations (hybrid systems) is discussed in [3]. A method for reducing the number of trajectory sensitivity calculations to get the most effective control is described in [4]. The use of TSA technique to investigate the Nordel power grid disturbance of January 1, 1997 is discussed in [5]. Application of TSA in transmission system protection to detect unstable power swings and electrical centers is described in [6]. The use of TSA in effective application of a TCSC controller in a multi-machine power system is discussed in [7]. Mathematical modeling and analysis of static compensator (STATCOM) is presented in [8]. Transient stability and power flow models of different FACTS devices are given in [9].

In this paper the effect of STATCOM in improving the transient stability condition of a power system is investigated. The sensitivities of state trajectories are used here to assess system stability margin. Fault in one of the lines is simulated as a contingency, which defines the nominal trajectory. Sensitivity is computed with respect to fault clearing time. Design of the STATCOM controller is carried out with the help of TSA. The effects of placement of STATCOM controllers at various locations of a power system on the transient stability are studied. Also the improvements in the post-fault steady state voltages at different load buses on application of the STATCOM are studied.

The STATCOM is represented here by a voltage source, which is connected to the system through a coupling transformer. The voltage of the source is in phase with the AC system voltage at the point of connection and the magnitude of the voltage is controllable. The systems under consideration are the WSCC 3-machine 9-bus system and the IEEE 16-machine 68-bus system. Load is modeled as constant impedance.

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doi:10.1016/j.ijepes.2010.12.005