

# Chapter 78

## A Descriptive Approach for Power System Stability and Security Assessment

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### ABSTRACT

*Power system dynamic analysis and security assessment are becoming more significant today due to increases in size and complexity from restructuring, emerging new uncertainties, integration of renewable energy sources, distributed generation, and micro grids. Precise modeling of all contributed elements/devices, understanding interactions in detail, and observing hidden dynamics using existing analysis tools/theorems are difficult, and even impossible.*

*In this chapter, the power system is considered as a continuum and the propagated electromechanical waves initiated by faults and other random events are studied to provide a new scheme for stability investigation of a large dimensional system. For this purpose, the measured electrical indices (such as rotor angle and bus voltage) following a fault in different points among the network are used, and the behavior of the propagated waves through the lines, nodes, and buses is analyzed. The impact of weak transmission links on a progressive electromechanical wave using energy function concept is addressed.*

*It is also emphasized that determining severity of a disturbance/contingency accurately, without considering the related electromechanical waves, hidden dynamics, and their properties is not secure enough. Considering these phenomena takes heavy and time consuming calculation, which is not suitable for online stability assessment problems. However, using a continuum model for a power system reduces the burden of complex calculations.*

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*Finally, a new power system emergency control framework based on descriptive study of electrical measurements and electromechanical wave propagation in large electric power systems is introduced. Since, fast and accurate detection of instability is essential in initiating certain emergency control measures, the proposed methodology could be also useful to detect the contingency condition and performing the well-known islanding and load shedding techniques. The chapter is supplemented by some illustrative nonlinear simulations on large scale test systems.*

## **1. INTRODUCTION**

Power system angle instability following loss of synchronism of the generators can be considered as a fast instability phenomena (Kundur, 1994, and Bevrani 2009). Detecting of this phenomena and performing adequate emergency actions are important issues to maintain the power system stability. When a disturbance takes place in a power system, the rotor angle of the generators near the occurred fault deviates from their base frames. This deviation propagates through the power system. So, for large disturbances, this may lead to the catastrophic outages, and finally blackout.

Because of deregulation and economical issues in power system management and fast growing of electrical power consumers, the transmission lines are usually working close to their stability limits. In other words, nowadays power systems are working under stress. One of problems that a stressed power system is encountered with, is the prediction of instability location. Occurring of a disturbance in a point of large scale power system may initiate instability in another point of the grid. In this chapter, it is shown that the reason of this problem can be found out from electrical wave propagation phenomenon and identifying the weak links of the system.

There are many research reports about wave traveling and propagation phenomenon (Thorp, 1998, Parashar, 2004, Phadke, 2008, Wagner, 1950, Sluis, 2001, Tsai, 2005 and Bank, 2007). Electromechanical wave propagation issue is well-discussed in (Thorp, 1998, Parashar, 2004, Phadke, 2008). They modeled a power system as a continuum. An online method for detection of loss of synchronism using an energy function

criterion is developed in (Padiyar, 2006). Several methodologies are also available to solve the same problem, using artificial neural networks, heuristic algorithms and intelligent schemes.

Emerging Phasor Measurement Units (PMUs) makes it possible to easily monitor the angle wave propagation throughout the power systems. They use Global Positioning Systems (GPS) to provide a synchronous time throughout the power systems which may be distributed through the continents. A methodology for islanding and identifying the weak links of a complex power system is proposed in (You, 2006 and Yang, 2006); they used the slow coherency approach.

In this chapter, first as a background, the different types of traveling waves in power systems and islanding control are addressed in Section 2. In Section 3, the problem at hand and the system modeling are described. In Sections 4 and 5, the islanding problem is re-analyzed concerning the wave propagation problem, and the proposed descriptive approach for power system stability assessment is explained. Some simulation results on two ring power system (64-bus and 200-bus), a 400-bus meshed system, and the 24-bus IEEE Reliability Test System (RTS-79) are presented. Further research directions are addressed in Section 6, and the chapter is concluded in Section 7.

## **2. BACKGROUND**

### **Wave Propagation**

Wave propagation is a phenomenon appeared in many studying fields. In civil engineering, for example, it is used to study on propagation of

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