Chapter 10
Power System Voltage Stability

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ABSTRACT

Understanding the voltage instability phenomenon and its effects in detail facilitates the research community to develop methodologies that can detect instability in a timely manner. Traditionally voltage instability in the system is identified through P-V and Q-V curves that are plotted using repetitive runs of load flow programs. It is observed that voltage stability is affected by the load dynamics, voltage control devices like OLTC, and hitting of over excitation limiters of the synchronous generators. In the following sections of this chapter, the concept of voltage instability with P-V and Q-V curves, load restoration mechanism with on load tap changer (OLTC), and with different types of loads are briefly presented.

INTRODUCTION

Increased load demand and deregulation of the power system makes the transmission lines operations close to the stability limits. This enforces increased reactive power demand on the system. Insufficient reactive power in the system leads to voltage problems. A system may be transiently stable but may not be able to maintain the voltage profile, which leads to voltage instability. Voltage instability incidents worldwide are due to insufficient reactive power in the system.

According to Prabha Kundur (1998) Voltage stability is the ability of the system to maintain acceptable voltages at all nodes in the system before and after the occurrence of a disturbance. The maintenance of acceptable voltages depends on the ability of the system to restore stable equilibrium between load demand and load supplied. Voltage instability leads to voltage collapse. Voltage collapse is progressive decline in voltage magnitude at electric power system load buses leading to complete or partial blackout as per Byung Ha Lee (1991). The occurrence of blackouts are rare but the repercussions are very severe. Prominent examples of blackouts due to voltage problems include North East of US in 2003

DOI: 10.4018/978-1-5225-8551-0.ch010

A. Atputharajah (2009), Athens blackout in 2004 Machowski (2008), Brazil blackout in 2009 Ordacgi Filho (2010), Indian grid blackout in July 2012 Vaishali Rampurkar (2016), Turkey blackout in 2015 Project Group Turkey (2015). Various blackout reports in W. R Lachs(1992), C. W Taylor (1997) and other literature Hemanthakumar Chappa (2018) confirms that voltage collapse occurs due to increased load demand or contingency under peak loaded conditions.

Understanding the voltage instability phenomenon and its effects in detail facilitates the research community to develop methodologies that can detect instability in a timely manner. Traditionally voltage instability in the system is identified through P-V and Q-V curves that are plotted using repetitive runs of load flow programs. It is observed that voltage stability is affected by the load dynamics, voltage control devices like OLTC and hitting of over excitation limiters of the synchronous generators.

In the following sections of this chapter the concept of voltage instability with P-V and Q-V curves, load restoration mechanism with on load tap changer (OLTC) and with different types of loads are briefly presented.

CONCEPT OF VOLTAGE INSTABILITY

Consider the two bus system shown in Figure 1, where E is generator terminal voltage and δ is the phase angle between generatorvoltage (E) and load voltage (V).

To compute the voltage instability condition, critical voltages and critical powers are to be calculated. For the Figure 1 the apparent power flow at the receiving end node is given as Carson W. Taylor (1994)

$$S = VI^{*} \tag{1}$$

$$I = \left[\frac{E\angle\delta - V}{jX}\right] \tag{2}$$

$$S = V\left[\frac{E\angle\delta - V}{jX}\right]^{*} \tag{3}$$

Figure 1. Simple two bus system