International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 8
August 2017

Improvement of Voltage Stability of IEEE 9 Bus System in PSCAD

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Abstract— The reconstructed power systems under deregulation are challenged to build in new transmission lines for accommodating significantly increased power transactions. Voltage stability is a reactive power problem and can be solved by providing suitable reactive power support at some critical buses. FACTS devices are being increasing used to provide not only the reactive power but also to control other aspects of a power system. Voltage instability problems increasing day by day because of huge increase demand in power. It is very important to analyze the power system with respect to voltage stability .This paper will be based on the voltage stability analysis of IEEE 9 BUS systems using SVC.

Keywords— Voltage Stability, Facts Devices, SVC, IEEE 9 Bus System.

I. Introduction

As the electric power systems have been evolved from last century, different forms of instability have been emerged during different period. Power system stability was first recognized as an important problem in 1920 which was associated with remote power plants feeding power to load centers over long transmission lines. The stability problem was caused due to slow exciters and non-continuously acting voltage regulators, which limits the power transfer capability by steady state as well as transient stability limits. It is widely known that exchanging active and reactive power with a power system can help to improve its steady state and transient performances. Modern power system is heavily stressed to meet the increasing demand. So the modern power system is facing challenges.

Flexible Alternating Current Transmission Systems (FACTS) are new devices originating from recent innovative technologies that are capable of altering voltage, phase angle and impedance at particular points in power systems. Their fast response offers a high potential for power system stability enhancement aside from steady-state flow control. Among the FACTS controllers, Static Var Compensator (SVC) provides fast acting dynamic reactive compensation for voltage support during contingency events which would otherwise depress the voltage for a significant length of time. SVC also damp out power swings and reduces system losses by optimized reactive power control. Power System Computer Aided Design (PSCAD) has been used in this paper to conduct simulations on voltage regulation and load flow capability at the point of connection of SVC to the system. The papers deals with the simulation of SVC on PSCAD and PWS along with the associated details of the circuit design.

II. VOLTAGE STABILITY

Voltage stability is becoming an increasing source of concern in present-day power systems. The problem of voltage instability is primarily considered as the inability of the network to meet the load demand imposed in terms of inadequate reactive power support or active power transmission capability or both. Voltage stability can be classified as small or large based on the disturbance type. Small voltage stability refers to the ability of the system to control the voltage when small perturbations occur, such as changes in the loads. Large voltage stability refers to the ability of the system to control the voltage after being subjected to large disturbances such as load outages, faults, and large-step changes in the loads. Voltage stability can be evaluated by two different methods of analysis: static and dynamic, the details of which are presented in the following subsection.

1. Static analysis

This method examines the viability of the equilibrium point represented by a specified operating condition of the power system. This method allows the examination of a wide range of system conditions. The electric utility industry depends on P-V and Q-V curves in order to determine stability at selected buses. The static method is evaluated by means of a variety of techniques such as:

a) Stability study using PV curves

P-V curves are generated by executing a large number of power flows using power flow methods. In this case, a power system is typically modeled with non-linear differential algebraic equations. The P-V curves are the most-used method of forecasting voltage security. They are used to determine the loading margin of a power system. The parameter P can either represent the total active power load in an area or the power flow across an interconnection between two areas and the state variable V is the voltage at a certain bus. The power system load is gradually increased and, at each increment, is necessary recomputed power flows until the nose of the PV curve is reached. The P-V curve is obtained by applying a optimal power flow method. The critical point or nose points in the P-V curve represents the maximum loading of a system. It can be written as P_{max}. The stability margin can be defined by the MW distant from the operating point to the critical point. The insertion of the Facts device in a power system can increase or decrease the voltage stability margin.

b) Q-V sensitivity analysis

In this method, the network is represented by a power flow equation that can be linearized. The Q-V sensitivity at a bus represents the slope of the Q-V curve (Figure 2) at a given operating point. A positive Q-V sensitivity is indicative of stable operation, and a negative sensitivity is indicative of unstable operation. Fig. 2 shows a typical QV curve.

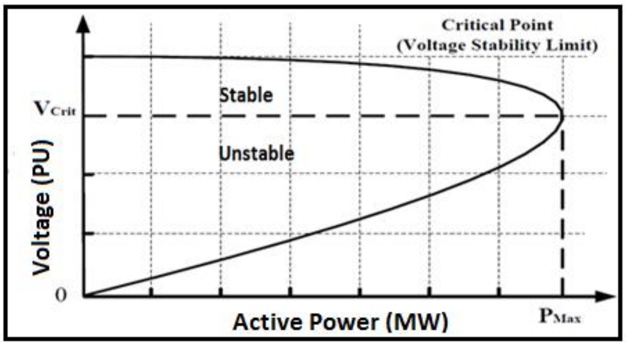

Figure 1: Typical PV curve

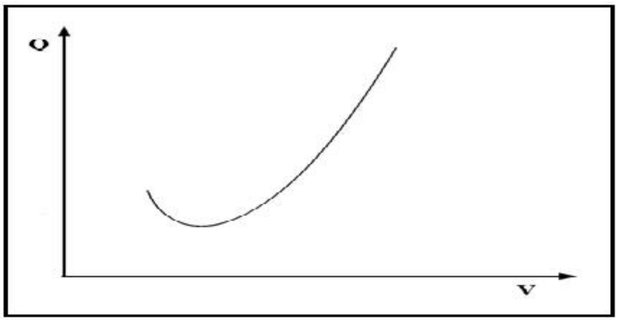

Figure 2: Q-V characteristic curve

2. Dynamic Analysis

Dynamic analysis can show the real behavior of the system such as loads (dynamic and static), DG units, automatic voltage and frequency control equipment, and the protection systems. The overall power system is represented by a set of first order differential equations, Voltage instability in distribution systems has been understood for decades and was referred to as load instability . For example, a voltage instability problem in a power system network, which was widespread to a corresponding transmission system, caused a major blackout in the S/SE Brazilian system in 1997. With the development of economy, load demands in distribution networks increase sharply. Hence, the power system networks are operating closer to the voltage instability boundaries. The decline of voltage stability margin is one of the most important factors which restrict the increase of load served by distribution companies. Therefore, it is necessary to consider voltage stability with the integration of FACTS device in power systems. The study considered the unbalance of loads and sources, and was divided into two parts: simulation without SVC FACTS device and then simulation with insertion of SVC FACTS device.

3. Proximity to voltage instability

As mentioned before, the static technique can be analyzed by using the relation between the receiving power (P) and the voltage (V) at a certain bus in a system, which is known as a P-V curve or nose curve. The P-V curve is obtained by applying the optimal power flow method. The critical point Pmax (saddle-node bifurcation point) in the P-V curve represents the maximum loading of a system. This point corresponds to a singularity of the Jacobian of the power flow equations. The stability margin can be defined by the MW distant from the operating point to the critical point. The insertion of the SVC device in a power system can increase or decrease the voltage stability margin depending on their loading capability as well as their location. Figure 1 illustrates a P-V curve of an electrical system. The x-axis represents P in MW, which is the scaling factor of the load demand at a certain operating point. P varies from zero to the maximum loading (Pmax). However, static analysis cannot determine the control action and the interaction between the SVC devices in the system. Proximity to the voltage instability method can be used to determine those issues. The impacts of the SVC device dynamics using small-signal stability analysis have analyzed in the literature. Small-signal stability analysis in power systems is achieved in frequency domain using Eigen value analysis. It is carried out by linearizing the mathematical model of the system and then solving for the Eigen values and Eigen vectors of the linearized model.

As referred in Figure 1 voltage stability is divided into two sections, i.e. large disturbance and small-disturbance. Large-disturbance voltage stability consists of maintaining bus voltages at a certain acceptable level after the system is subjected to a large disturbance (system faults, loss of generation or presence of contingencies). Whereas, small-disturbance voltage stability involves maintaining steady voltages following small perturbations in the system such as load variations. For all types of disturbances, the time frame of interest varies from a few seconds to several minutes. Figure shows that the time frame is divided into short-term and long term voltage stability. Short-term voltage stability consists of the dynamics of the components of the system shortly after a disturbance. Short-term instability often arises due to the presence of fast acting load components such as induction motor loads, high penetration of distributed generation that is consuming reactive power without voltage control, electronically controlled loads and HVDC converters. Long-term voltage stability is mainly studied using static analysis for large-scale power systems under various conditions. Equipment considered for this time scale consists mainly of tap-changing transformers, thermostatically controlled loads and generator current limiters. The main causes of long-term instability include

1. Loss of a long-term equilibrium operating point
2. Lack of reaching a stable post-disturbance equilibrium due to the effect of over excitation limiters
3. Tap changers reaching their limits or when operating near a small-disturbance instability.

III. STATIC VAR COMPENSATOR

According to the IEEE definition, a Static Var Compensator (SVC) is a shunt connected static var generator or absorber whose output is adjusted to exchange capacitive or inductive current to maintain or control specific parameters of the electrical power system (typically, the bus voltage). It helps in voltage regulation, reactive power control and improving the transient stability of the system. Static VAR Compensator (SVC) is a first generation FACTS device that can control voltage at the required bus thereby improving the voltage profile of the system

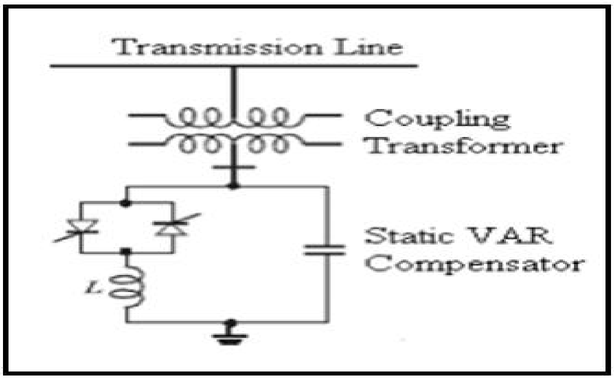

Figure 3: Schematic Diagram of SVC

This compensator consist of a fast thyristor switch controlling a reactor and/or shunt capacitor bank to provide dynamic shunt compensation. SVC is shunt connected Static Var Generator/Load whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific power system variables.

SVC can be used for

- Static and Dynamic Voltage Control
- Oscillation Damping
- Sub Synchronous Resonance
- Reactive Power Support
- To increase power transfer capability

IV. IEEE 9 BUS SYSTEM

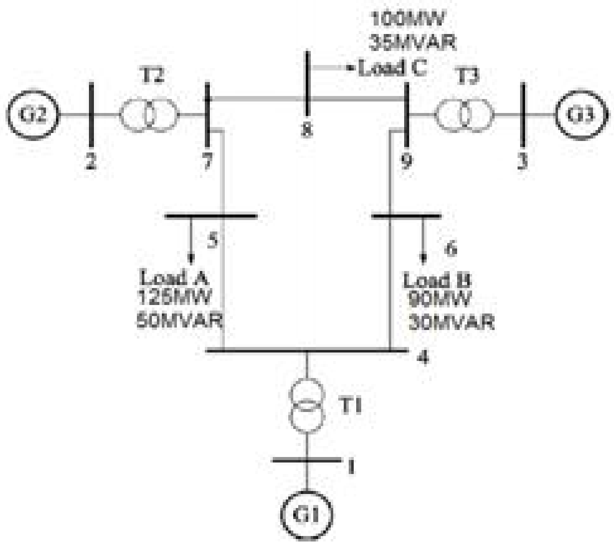

Figure 4: Single Line Diagram of IEEE 9 bus system

IEEE 9 bus system contains 6 transmission line of 1 m length each which are interconnected to buses as shown in Fig. 5.1 Fundamental system frequency is 60 Hz and base voltage is 230 kV .Three generators of base 77, 163 and 86 MVA are connected to bus 1, bus2 and bus 3 respectively. Whereas, loads are connected at bus no 5, 6 and 8.

V. RESULTS AND DISCUSSION

Loading Without SVC

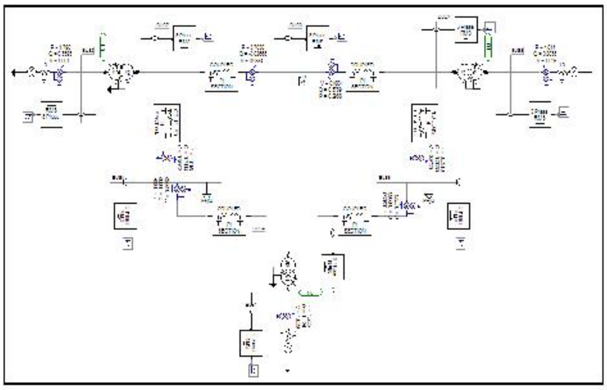

Figure 5: Simulation of IEEE 9 bus Test system model during Loading condition without SVC in PSCAD

Fig. 5 shows simulation of IEEE 9 bus Test system in PSCAD software during normal and loading condition in which PI section transmission lines of 1 m are used for connecting various buses. Sources are connected to buses 1, 2 and 3. Loads are connected to bus No.5, 6 and 8. Three transformers are connected between bus 1 and 4,bus 2 and 7, bus 3 and 9. Multimeters are connected between each line for measuring voltage,current,active and reactive power flowing through the line. Also voltmeters are connected on each bus for measuring Line volatge in pu on each bus.

Loading with SVC

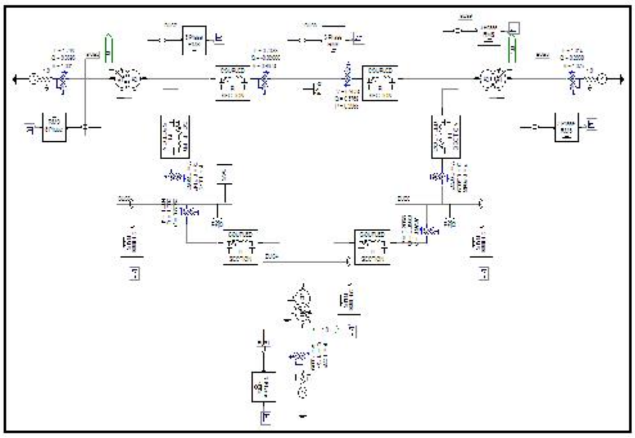

Figure 6: Simulation of IEEE 9 bus Test system model during loading condition with SVC in PSCAD.

Fig 6 shows simulation of IEEE 9 bus Test system in PSCAD Software for different loading condition with connecting SVC at bus no 5.

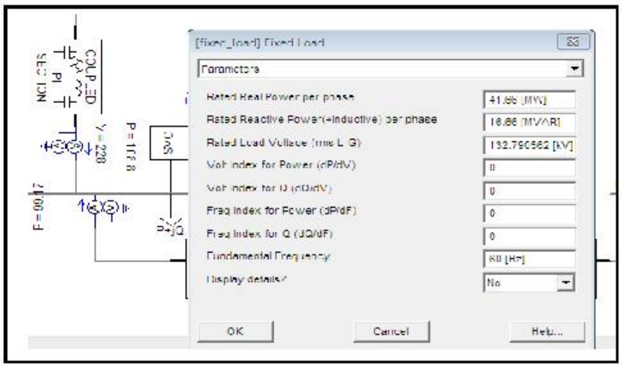

Figure 7: Loading condition changed using fixed load parameter

Fig. 7 shows the loading part of 9 bus system in PSCAD software. So from this parameter we changed the load according to our convenient need.

VI. CONCLUSIONS

In this paper, the basic structure of an SVC operating under typical bus voltage control and its model are described. This study, the effectiveness of shunt FACTS devices such as SVC has been studied in improving the system stability of an IEEE 9 bus system. The simulation results shown here shows the effective working of SVC.

REFERENCES

[1] S IEEE Special Stability Controls Working Group "Static Var Compensator Models for Power Flow and Dynamic Performance Simulation" IEEE Transactions on Power Systems, Vol. 9, No. 1, February 1994

[2] Olimpo Anaya-Lara and E. Acha "Modeling and Analysis of Custom Power Systems by PSCAD/EMTDC IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 17, NO. 1, JANUARY 2002

[3] Gagari Deb, Kabir Chakrabortl and Sumita Deb "Voltage Stability Analysis using Reactive Power Loading as indicator and 1ts 1mprovement by FACTS Device" 1st IEEE International Conference on Power Electronics. Intelligent Control and Energy Systems (ICPEICES-2016)

[4] RenukaKamdar, Manoj Kumar, Ganga Agnihotri "Transient Stability Analysis And Enhancement of IEEE-9 Bus System"Electrical & Computer Engineering: An International Journal (ECIJ) Volume 3, Number 2, June 2014

[5] Mark Ndubuka NWOHU "Voltage Stability Improvement using Static Var Compensator in Power Systems" Department of Electrical/Computer Engineering, Federal University of Technology, Minna, Niger State, Nigeria Leonardo Journal of Sciences ISSN 1583-0233 Issue 14, January-June 2009 p. 167-172

[6] B. T. Ramakrishna Rao, N. Gaytri, P. Balaji, K. Sindhu "Modeling and Simulation of Static Var Compensator Controller for Improvement of Voltage