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A Review of Svc and Statcom

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ABSTRACT

One of the real reasons for voltage insecurity is the responsive power utmost of the framework. Enhancing the framework's receptive power taking care of limit by means of Flexible AC transmission System (FACTS) gadgets is a solution for evasion of voltage precariousness and consequently voltage crumple. In this paper, the impacts of SVC and STATCOM in Static Voltage Stability Margin Enhancement will be talked about. Air conditioning and DC portrayals of SVC and STATCOM are utilized as a part of the continuation control stream process in static voltage security consider.

Keywords: SVC, STATCOM, Voltage Collapse, Maximum Loading Point.

I. INTRODUCTION

In recent years, the increase in peak load demand and power transfers between utilities has elevated concerns about system voltage security. Voltage collapse has been deemed research efforts are under way in an effort to further understand voltage phenomena. A large portion of this research is concentrated on the steady state aspects of voltage stability. Indeed, numerous authors have proposed voltage stability indexes based upon some type of power flow analysis. A particular difficulty being encountered in such research is that the Jacobian of a Newton-Raphson power flow becomes singular at the steady state voltage stability limit.

In fact, this stability limit, also called the critical point, is often defined as the point where the power flow Jacobian is singular. As a consequence, attempts at power flow solutions near the critical point are prone to divergence and error. For this reason, double precision computation and anti divergence algorithms have been used in attempts to overcome the numerical instability [1].

Voltage instability is mainly associated with reactive power imbalance. The loadability of a bus in the power system depends on the reactive power support that the bus can receive from the system. As the system approaches the Maximum Loading Point (MLP) or voltage collapse point, both real and reactive power losses increase rapidly. Therefore, the reactive power supports have to be local and adequate.

There are two types of voltage stability based on the time frame of simulation: static voltage stability and dynamic voltage stability.

Static analysis involves only the solution of algebraic equations and therefore is computationally less extensive than dynamic analysis. Static voltage stability is ideal for the bulk of studies in which voltage stability limit for many pre- contingency and post-contingency cases must be determined.

In static voltage stability, slowly developing changes in the power system occur that eventually lead to a shortage of reactive power and declining voltage. This phenomenon can be seen from the plot of the power transferred versus the voltage at receiving end. The plots are popularly referred to as P-V curve or “Nose” curve. As the power transfer increases, the voltage at the receiving end decreases. Eventually, the critical (nose) point, the point at which the system reactive power is short in supply, is reached where any further increase in active power transfer will lead to very rapid decrease in voltage magnitude. Before reaching the critical point, the large voltage drop due to heavy reactive power losses can be observed.

The only way to save the system from voltage collapse is to reduce the reactive power load or add additional reactive power prior to reaching the point of voltage collapse [2].

Voltage collapse phenomena in power systems have become one of the important concerns in the power industry over the last two decades, as this has been the major reason for several major blackouts that have occurred throughout the world including the recent Northeast Power outage in North America in August 2003 [3]. Point of collapse method and continuation method are used for voltage collapse studies [4]. Of these two techniques continuation power flow method is used for voltage analysis. These techniques involve the identification of the system equilibrium points or voltage collapse points where the related power flow Jacobian becomes singular [5, 6].

Usually, placing adequate reactive power support at the "weakest bus" enhances static-voltage stability margins. The weakest bus is defined as the bus, which is nearest to experiencing a voltage collapse. Equivalently, the weakest bus is one that has a large ratio of differential change in voltage to differential change in load (∂V / ∂PTotal). Changes in voltage at each bus for a given change in system load is available from the tangent vector, which can be readily obtained from the predictor steps in the CPF process. In addition to the above method, the weakest bus could be obtained by looking at right eigen vectors associated with the smallest eigen value as well.

Reactive power support can be done with FACTS devices. Each FACTS device has different characteristics; some of them may be problematic as far as the static voltage stability is concerned. Therefore, it is important to study their behaviors in order to use them effectively.

Canizares and Faur studied the effects of SVC and TCSC on voltage collapse [7]. Study of STATCOM and UPFC Controllers for Voltage Stability Evaluated by Saddle-Node Bifurcation Analysis is carry out in [8]. In this paper is to compare the merits and demerits of two FACTS devices, namely, SVC and STATCOM in terms of Maximum Loading Point (MLP) in static voltage collapse study.

Rest of the paper is organized as follows: Section II briefly introduces the basic mathematical tools required for the analysis of voltage collapse phenomena. A brief introduction of the stability models including AC and DC representations of SVC and STATCOM is presented.

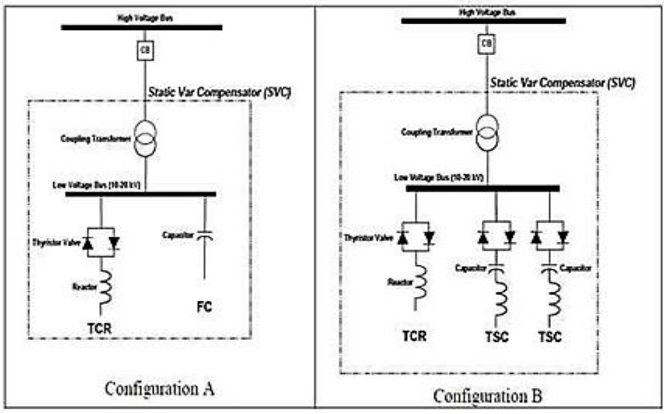
II. VOLTAGE COLLAPSE

Voltage collapse studies and their related tools are typically based on the following general mathematical descriptions of the system [9]: margin in P.U., %, MW or MVA depending on how the load variation are defined. Based on bifurcation theory, two basic tools have been defined and applied to computation of this collapse point, namely, direct and continuation methods.

In voltage collapse studies, the continuation method shows many advantages, so, most of the researchers apply this technique to trace voltage profile at various buses of the test power system, with respect to changes of loading level λ, namely, Continuation Power Flow (CPF).

In this paper the continuation power flow algorithm with smooth changes of loading level at various buses of the system, is chosen for simulation purpose.

There are two types of FACTS devices considered in this study, namely, SVC and STATCOM. Details including basic structures and terminal characteristics of these FACTS devices are presented in the following section.



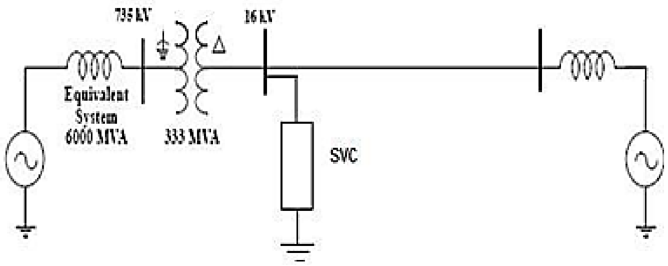
$$\dot{x} = f(x, y, \lambda, p)$$

$$0 = g(x, y, \lambda, p) \tag{1}$$

Where $x \in \Re^n$ represents the system state variables, corresponding to dynamical states of generators, loads, and any other time varying element in the system such as FACTS devices; $y \in \Re^n$ corresponds to the algebraic variables, usually associated to the transmission system and steady state element models, such as some generators and loads in the network; $\lambda \in$

ℜ k stands for a set of uncontrolled parameters that drive the system to voltage collapse, which are typically used to represent system demand. Vector p ∈ℜk is used here to represent system parameters that are directly controllable, such as shunt and series compensation levels.

Based on equation (1) the voltage collapse point may be defined, under certain assumptions, as the equilibrium point where the related system Jacobian is singular, i.e. the point among these two setups, the second (TSC-TCR) minimizes stand-by losses; however from a steady-state point of view, this is equivalent to the FC-TCR. In this paper, the FC-TCR structure is used for analysis of SVC which is shown in figure 1.



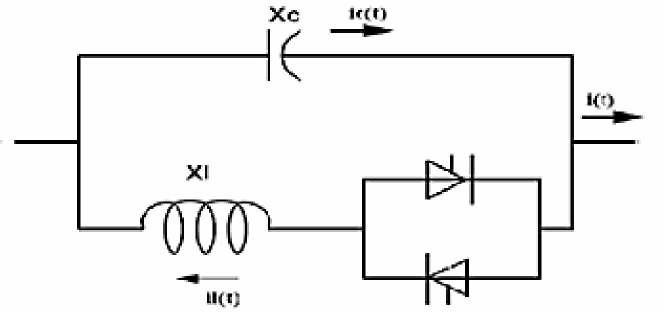


Figure 1. Equivalent FC-TCR circuit of SVC.

(x , y , λ , p) where and D F0has a zero eigenvalue. This equblirium is typically associated to a saddle-node bifurcation point. For a given set of controllable parameters P , voltage collapse studies usually concentrate on determining the collapse or bifurcation point (x , y , λ) , where λ typically corresponds to the maximum loading level or loadability

III. MODELLING OF SVC

For steady state analysis, it is adequate to model the steady state control characteristics of SVC. Even for transient stability studies, where low frequency phenomena are of interest, and AC network transients are neglected, steady state representation of SVC may be adequate as a first approximation. However to model the damping contribution of SVC, it is necessary to consider the dynamics of SVC controller. Here the output is *Bsvc* and the delays introduced by the GPG are modelled approximately by the transfer function

Gc (s) = e-sTd/1 + sT s' (8)

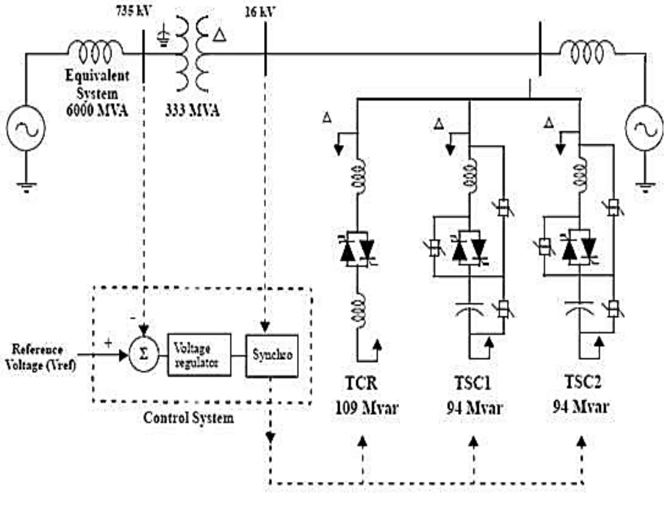
where *Td* is approximately *T* /12 for a six pulse converter and *Ts* is *T* /4 where *T* is the period of supply voltage. *Tm* represents the transducer time constant. Filters are neglected in this model.

The output of SVC is a time-varying susceptance *Bsvc*. The inclusion of this in the network results in a time varying admittance matrix which can be problematic. The inclusion of a single SVC in the network can be handled by the use of compensation theorem which enables the calculation of SVC current using Thevenin's equivalent of the network at the SVC bus. This equivalent has to be updated at every time step when SVC current is to be calculated.

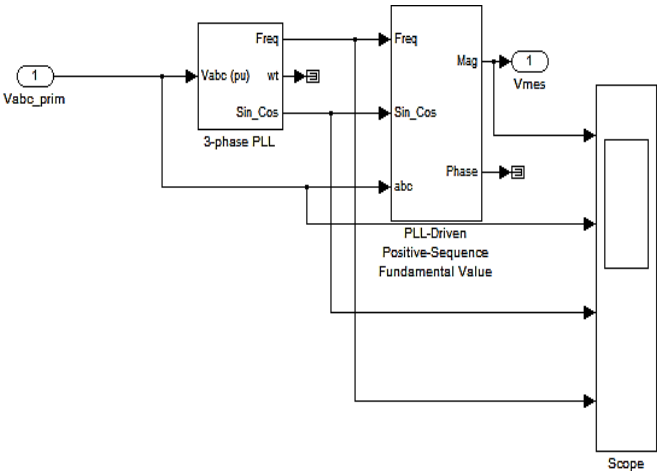
The single line diagram shown below represents a simple 735 kV transmission

A 1000 MW hydraulic generation plant (M1) is connected to a load center through a long 500 kV, 700 km transmission line. The load center is modeled by a 5000 MW resistive load. The load is fed by the remote 1000 MVA plant and a local generation of 5000 MVA plant (M2).

A load flow has been performed on this system with



A 300-Mvar Static Var Compensator (SVC) regulates voltage on a 6000-MVA 735-kV system. The SVC consists of a 735kV/16-kV 333-MVA coupling transformer, one 109-Mvar thyristor- controlled reactor bank (TCR) and two 94-Mvar thyristor-switched capacitor banks (TSC1, TSC2) connected on the secondary side of the transformer. Switching the TSCs in and out allows a discrete variation of the secondary reactive power from zero to 188 Mvar capacitive (at 16 kV) by steps of 94 Mvar, whereas phase control of the TCR allows a continuous variation from zero to 109 Mvar inductive. Taking into account the leakage reactance of the transformer (15%), the SVC equivalent susceptance seen from the primary side can be varied continuously from -1.04 pu/100 MVA (fully inductive) to +3.23 pu/100 Mvar (fully capacitive). The SVC controller monitors the primary voltage and sends appropriate pulses to the 24 thyristors (6 thyristors per three-phase bank) in order to obtain the susceptance required by the voltage regulator.



For steady state analysis, it is adequate to model the steady state control characteristics of SVC. Even for transient stabilit y studies, where low frequency phenomena are of interest, and AC network transients are neglected, steady state representation of SVC may be adequate as a first approximation. However to model the damping contribution of SVC, it is necessary to consider the dynamics of SVC controller. Using of SVC and STATCOM give the view of voltage decline before entering to the collapse point. The SVC and STATCOM significantly affects the shape of the PV curve, which improves the critical point without masking the nose point by only shift out the PV curve.

SVC and STATCOM provides a better voltage profile at the collapse point compared to other FACTS devices. This is due to the reason that the both are installed at the weakest bus. Reactive power support at the weakest bus provides better voltage profiles throughout the system. SVC and STATCOM introduces reactive power at weak es t bus, which improves voltage profile in its vicinity.

IV. CONCLUSIONS

A comparison study of SVC and STATCOM in static voltage stability margin enhancement is presented. SVC and STATCOM increase static voltage stability margin and power transfer capability. In this paper the SVC and STATCOM in the steady- state studies are presented and thoroughly discussed. Hence, a technique to identify the optimal placement of the FACTS devices and related equations are derived.

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