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Dynamic Performance of Power Transmission system improvement using Static Var Compensator

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ABSTRACT: This paper presents for discuses how Static Var Compensator (SVC) has successfully been applied to control transmission systems dynamic performance for system disturbance and regulate system voltage and power flow models of static Var compensator (SVC) and current Sourced Inverter (CSI) based Flexible AC Transmission System (FACTS) Controllers. SVC is basically a shunt compensative device. The static Var generator whose output is adjustable limits to exchange capacitive or inductive current so as to maintain or control specific power variable; typically, the control variable is the SVC bus voltage. One of the major reasons for installing a SVC is to improve dynamic performance control and thus increase system reliability. 'This paper presents a control block diagram of SVC for the dynamics performance improvement. The MATLAB/SIMULINK model is used for simulation of test system. In this paper the SVC is connected to shunt with the 220KV line for a typical two machine transmission system. Due to its simplicity, robustness and easy implementation, proportional integral derivative (PID) controller along with feedback signals are used to control the inverter firing angle and hence control the reactive power exchange between the AC system and the SVC.

Keywords: FACTS, SVC, Voltage control, Current Source Inverter (CSI), Dynamics performance, PID controller and PSS.

I. INTRODUCTION

Today's power transmission and distribution systems face increasing demands for more power, better quality at lower cost, as well as low environmental effect. Under these conditions, transmission networks are called upon to operate at high transmission levels**.** In analyzing dynamic phenomenon in power systems, close attention has generally been given to the modeling of generators, their applicable controls, and transmission equipment. And the representation of loads has not conventionally been considered so thoroughly, even though it has been known since the 1930's that accurate representation of loads is necessary in power systems stability [1]. It has been shown in a number of reports that power system loads can have a significant impact on the dynamics of the system, especially voltage profile. Unfortunately, the accurate modeling of loads is a difficult task due to several factors such as: large number of different load components; ownership and location of load devices in customer facilities that are not directly compatibility to the electric utility; changing load composition with the time of day and week, seasonable condition; lack of precise information on the composition of loads; uncertainties regarding the characteristics of many load components; difficulties in measurement for different range of voltage and frequency variations.

Thus, a universally acceptable dynamic load model does not exist, and a specific load model is chosen depending on the type measurement and analysis. The various types of power system loads, however, are not dependent on voltage or frequency, but actually depend upon dynamic characteristics. Under steady state condition some major operating problems such as transient stability, damping of oscillations and voltage regulation etc [2].

To solving this type of problem application of "Flexible AC Transmission System" (FACTs) controller technologies, such as the Static Var Compensator (SVC) is used. In an ideal alternating current power system, the voltage and frequency at each supply point should be constant and free from all type harmonics; the power factor should be unity. There are two types of voltage stability: transient voltage stability and longer-term voltage stability. Longer-term voltage stability includes loads that are voltage sensitive. Voltage stability includes the load, transmission, and generation-sub systems of large power systems.

To improve voltage stability, and damped low frequency oscillation for the transmission system. The Design and tuning of power system stabilizer involved in the development of power systems control. It is because of inaccurate controlling of power system stabilizer that causes damping oscillations and contributes to the amplification of instability leading to the loss of synchronism.

And using PID controller concept applied with Static Var Compensator (SVC) which improves the dynamics response and reactive power control [3].

II. STATIC VAR COMPENSATOR (SVC)

The SVC is the most widely employed FACTS Controller. It is a shunt-connected static Var generator or absorber whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific parameters of the electrical power system (typically bus voltage). The general configuration of the SVC is essentially a controllable inductor in parallel with a switchable capacitance. In order to prevent the thyristor valves from being subjected to excessive thermal stresses the maximum inductive current in the overload range is constrained to a constant value by an additional control action [4].

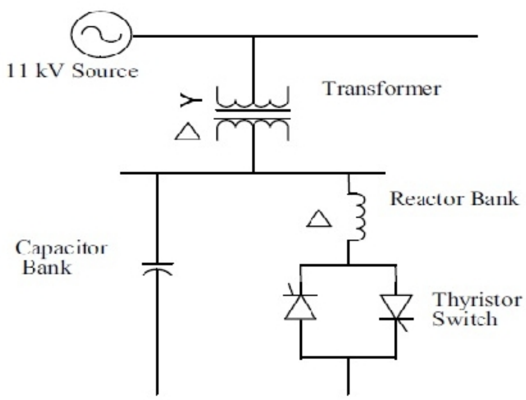

Fig. 1. The SVC diagram of exchange power from the ac system.

III. THE V-I CHARACTERISTIC

The dynamic V-I characteristics of the SVC is described by its linear range of control over which SVC terminal voltage varies linearly with SVC current as the latter is varied over its entire capacitive to inductive range.

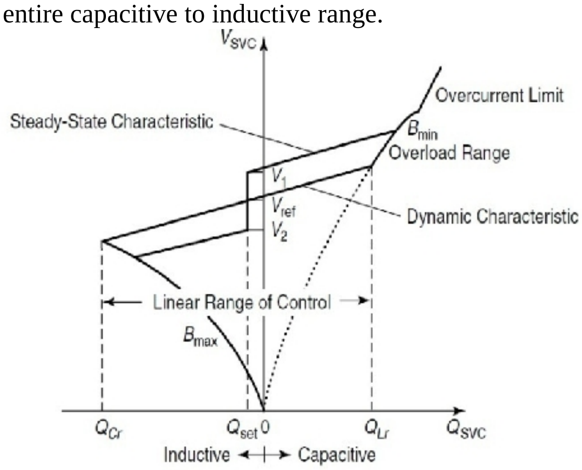

Fig. 2. The *V-I* characteristic of the SVC.

When the SVC traverses outside the linear controllable range on the inductive side the SVC enters the overload zone where it behaves like a fixed inductor. A small slope (2-3%) is incorporated in the V-I characteristic for improved SVC operation. The steady state *V-I* characteristic of an SVC is very similar to the dynamic *V-I* characteristic [5] except for a dead band in voltage. In the absence of this dead band, in steady-state, the SVC will have a tendency to drift towards its reactive power limits to provide voltage regulation, thus undesirably limiting the dynamic range of SVC available for system performance improvement.

IV. MODEL OF SVC IN POWER SYSTEM

Without losing synchronism, a three-bus system SVC controller shown in Fig.3 is employed to derive the model. It is the identically case where power is transmitted through an electrical transmission line connecting two generating stations and loads at its sending and receiving end. It should be noted that except the SVC parameters, all the transmission network parameters are not known in practice.

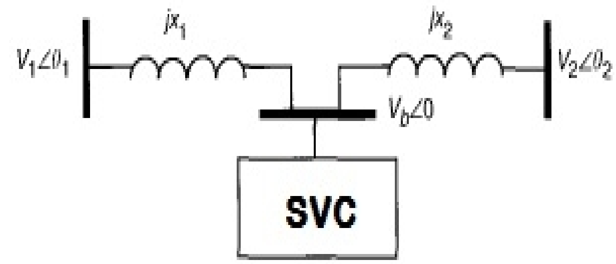

Fig. 3. Three bus system model with SVC.

V. POWER SYSTEM STABILIZER (PSS)

Power system stabilizer has been extensively used as excitation controllers to damp out the low frequency oscillations and enhance the overall system stability. Fixed structure stabilizers have practical applications and generally provide acceptable dynamic performance. There have been arguments that these controllers, being tuned for nominal operating condition. There are two main approaches to stabilize a power system over a wide range of operating conditions, namely robust control [6].

VI. MODELLING OF SVC

The SVC is basically a shunt connected static var generator or load whose output can be adjusted to exchange capacitive or inductive current so as to maintain or control specific power system variables; typically the controlled variable is the bus voltage. One of the major reasons for installing an SVC is to improve dynamic voltage control and thus increase system load ability. A single phase MATLAB model of SVC that has fixed capacitor *c* in parallel with a Thyristor Controlled Reactor (TCR) [7].

The overall compensator susceptance B_{svc} can be defined with the following equation

$$I_{SVC} = VjB_{SVC}$$

In the simple case of a TCR, the compensator susceptance is

$$B_{SVC} = B_{TCR}$$

VII. SVC IN POWER SYSTEM

There are two machine three bus systems, which are very important characteristics to describe the behavior of system, it is extremely useful to explain the general concepts of power systems dynamic performance and is relatively simple to study [8]. During the faulty condition the transmitted electrical power suddenly decreases significantly while mechanical input power to generator remains constant, consequently, the generator continuously accelerates as can be seen in the generator speed and power angle.

When the faulty condition is recovered, the speed is continuously increasing and system is unable to retain stability due to the lack of damping. During course of the fault, the generator terminal experiences voltage sag without the SVC as shown in fig 5. This voltage is not recovered after the fault clearance due to the insufficient reactive power support, the shaft of the turbine generator set are caused high torsion oscillations and force as seen in the electromechanical torques.

If the proper compensation of the ac power system requires some specific variation in the amplitude of the terminal voltage with time or some other variable, then an appropriate correcting signal derived from the auxiliary inputs, is summed to the fixed reference V_{Ref} in order to obtain the desired effective (variable) reference signal V_{Ref} that closed-loop controls the terminal voltage V_T.

As the SVC is connected to the system midpoint terminals, SVC controller adapts the value of the inverter firing angle according to system requirements [9-10]. As shown in Fig.7 the firing angle should remain zero at normal operating conditions and there is no reactive power exchange between the system and the SVC. When the fault occurs, the angle is changed instantly and the reactive power is supplied by the SVC to the system. When the system is recovered faulty condition, the firing angle is reduced to zero again and the SVC back to the idle condition.

VIII. EXPERIMENTAL TEST SYSTEM

In the test of dynamic performance of system for obtaining more practical results, the proposed MATLAB/ SIMULINK control scheme is used. The real time operation can be achieved, it can be applied in areas traditionally reserved for analogue simulators, e.g. testing of protective relays and testing of system controller. Two machine three bus system of a power system for evaluating the proposed PID controller design method is considered.

Using this model, we consider a typical two 500MW, 11KV, 50Hz synchronous generator to connect with a 500MVA, 11/220KV two transformers and two transmission lines are 220KV, 300KM and 220MVAR SVC connected to three buses. Single line diagram of the model is shown in Fig. 4.

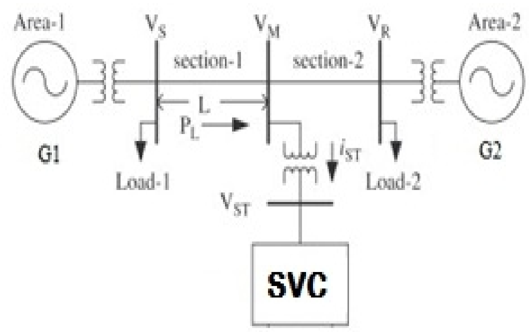

Fig. 4. Single line diagram of Model.

XI. SIMULATION AND RESULTS

This model, performance of controller is evaluated conventional from IEEE standard. The simulations carried out using MATLAB/ SIMULINK environment for power system for evaluating robustness of proposed PSS stabilizations of these PSSs is simulated of disturbances.

1. Without SVC- Shows rotor d_theta angle instability of synchronous generator, angular velocity ω1 and ω2 and terminal voltage unstable due to occurs single phase fault on a generator bus. When no compensation allows in the system.

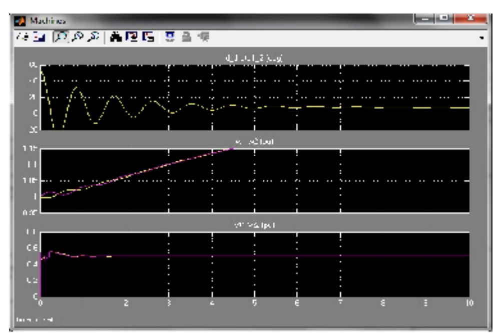

Fig. 5. Rotor d_theta angle of without SVC.

2. **With SVC**- Shows rotor d theta angle stability of synchronous generator, angular velocity ω1 and ω2 and terminal voltage stable single phase fault on a generator bus.

When compensation allows-

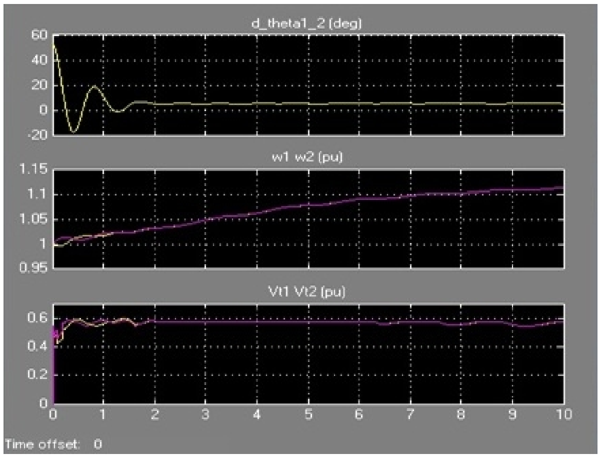

Fig. 6. Rotor d_theta angle of with SVC.

3. This simulation result shows that line power fluctuation and bus voltage fluctuation Without SVC.

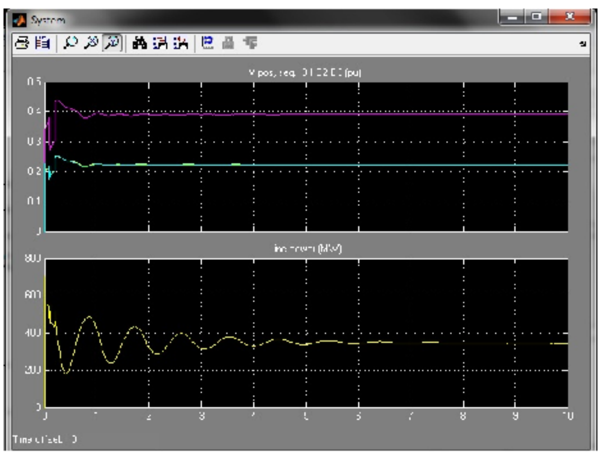

Fig. 7. Line power (MW) and bus voltage without SVC.

4. This simulation result shows that line power fluctuation and bus voltage fluctuation With SVC.

VIII. CONCLUSION

This paper has investigated the power system dynamic characteristic of SVC, and then described the switch strategy of internal and external fault based on two generating station. The simulation result shows: SVC considered in transmission line can damp power oscillation efficiently, and different switch modes result different effect especially when internal fault. The bypass mode reaches the best effect in the three modes when internal fault, and also avoids the impulse voltage and current. The effects on power compensation and damping low-frequency oscillation of SVC for the three-phase short-circuit of the same line were studied and compared based on the simulation.

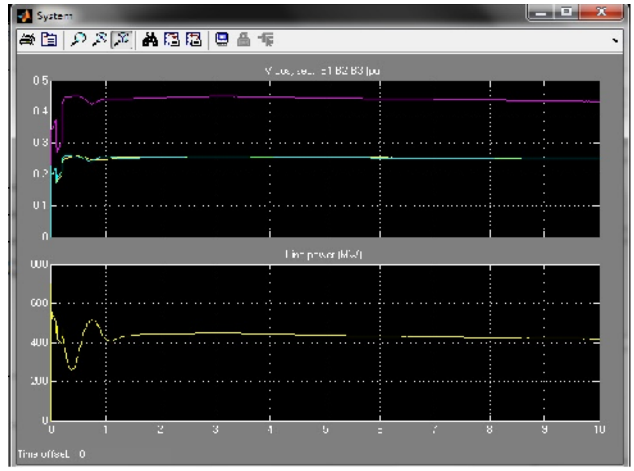

Fig. 8. Line power (MW) and bus voltage with SVC.

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