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Steady-State and Dynamic Performance of the Static Var Compensator (SVC) Phasor Model

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Abstract

A static var compensator (SVC) is used to regulate voltage on a 500 kV, 3000 MVA system. When system voltage is low the SVC generates reactive power (SVC capacitive). When system voltage is high it absorbs reactive power (SVC inductive). The SVC is rated +200 Mvar capacitive and 100 Mvar inductive. The Static Var Compensator block is a phasor model representing the SVC static and dynamic characteristics at the system fundamental frequency.

Index terms— Static var compensator (SVC)

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Introduction

Static Var Compensators are used in transmission and distribution networks mainly providing dynamic voltage support in response to system disturbances and balancing the reactive power demand of large and fluctuating industrial loads. A Static Var Compensator is capable of both generating and absorbing variable reactive power continuously as opposed to discrete values of fixed and switched shunt capacitors or reactors. Further improved system steady state performance can be obtained from SVC applications. With continuously variable reactive power supply, the voltage at the SVC bus may be maintained smoothly over a wide range of active power transfers or system loading conditions. This entails the reduction of network losses and provision of adequate power quality to the electric energy end-users

In recent years, with the deregulation of the electricity market, the traditional concepts and practices of power systems have changed. Better utilization of the existing power system to increase power transfer capability by installing FACTS (Flexible AC Transmission Systems) devices becomes imperative [1, 10]. The parameter and variables of the transmission line, i.e. line impedance, terminal voltages, and voltage angles can be controlled by FACTS devices in a fast and effective way [10, 12]. The benefit brought about by FACTS includes improvement of system dynamic behavior and thus enhancement of system reliability. However, their main function is to control power flows [2,4]. Provided that they are placed at optimal locations, FACTS devices are capable of increasing the system loadability too [1]. These aspects are playing an increasingly significant role in the operation and control of the deregulated electricity market. Many researches were made on the optimal allocation of FACTS devices [1-3]. However, the investment cost of FACTS and their impact on bid curves of the market participants (suppliers and consumers) in a liberalized electricity market are not wholly considered [8]

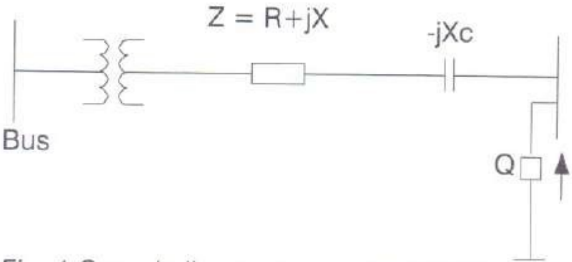


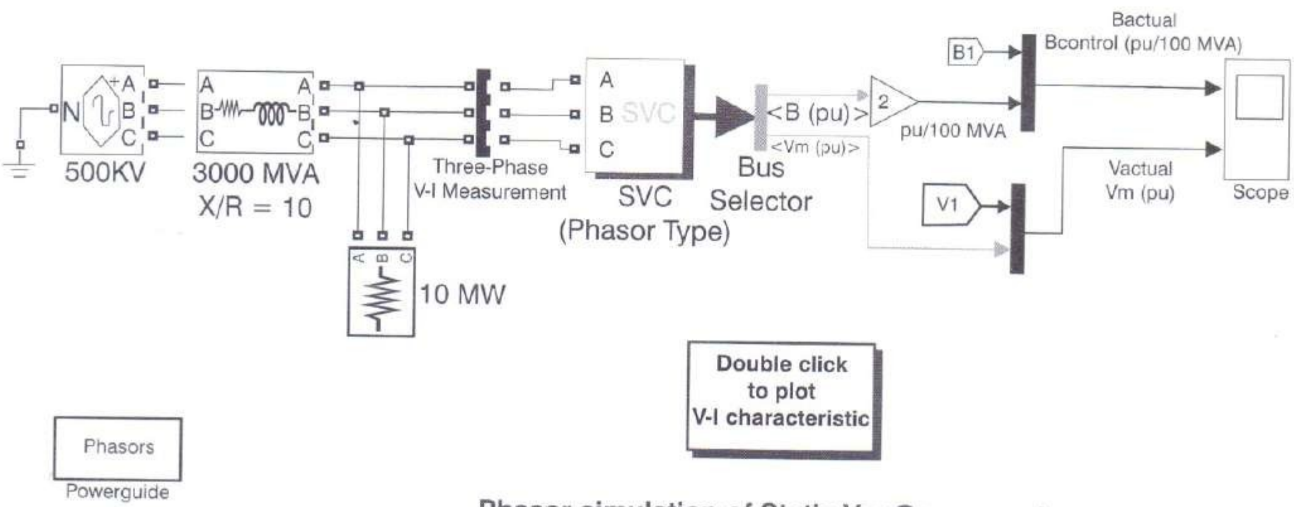
Fig. 1 Generic line segment with FACTS paramaters

Principle of operation

Static Var Compensators (SVC) are the most popular devices of FACTS. The main functionality of the SVC is to regulate the voltage at a chosen bus by controlling the reactive power injection at the location. Maintaining the rated voltage levels is important for proper operation and utilization of loads. Under voltage causes deregulation in the performance of loads such as induction motors, light bulbs, etc., whereas over voltage causes magnetic saturation and resultant harmonic generation, as well as equipment failures due to insulation breakdown. These devices are characterised by rapid response, wide operational range and high reliability. SVC based on thyristors without the gate turn-off capability is considered as a shunt-connected static VAR generator or absorber.Their output is adjusted to exchange capacitive or inductive current. As an important component for voltage control, it is usually installed at the receiving bus. In the formulation, the SVC has been considered a shunt branch with a compensated reactive power setting by available inductive and capacitive susceptances.

III Measurement of steady-state V-I characteristic

Fig. 1 shows the generic line segment with FACTS parameters. In order to measure the SVC steady-state V-I characteristic, you will now program a slow variation of the source voltage. Open the Programmable Voltage Source menu and change the "Type of Variation" parameter to "Modulation". The modulation parameters are set to apply a sinusoidal variation of the positive-sequence voltage between 0.75 and 1.25 pu in 20 seconds. In the Simulation->Configuration Parameters menu change the stop time to 20 s and restart simulation. When simulation is



Phasor simulation of Static Var Compensator

Fig. 2 Schematic diagram for simulation of SVC completed, double click the blue block. The theoretical V-I characteristic is displayed (in red) together with the measured characteristic (in blue)

Simulation of dynamic performance of SVC

Using MATLAB simulink software along with its SIMULINK and SIMPOWERSYSTEM toolboxes, this SVC is simulated. Fig. 2 shows the schematic diagram for dynamic performance of SVC phasor model.

Results and Discussions

The Three-Phase Programmable Voltage Source is used to vary the system voltage and observe the SVC performance. Initially the source is generating nominal voltage. Then, voltage is successively decreased (0.97 pu at t = 0.1 s), increased (1.03 pu at t = 0.4 s) and finally returned to nominal voltage (1 pu at t = 0.7 s). Start the simulation and observe the SVC dynamic response to voltage steps on the scope. Trace 1 show the actual positive-sequence susceptance B1 and control signal output B of the voltage regulator. Trace 2 shows the actual system positive-sequence voltage V1 and output Vm of the SVC measurement system.

The SVC response speed depends on the voltage regulator integral gain Ki (Proportional gain Kp is set to zero), system strength (reactance Xn) and droop (reactance Xs). If the voltage measurement time constant and average time delay Td due to valve firing is neglected, the system can be approximated by a first order system having a closed loop time constant

$$T_c = \frac{1}{(K1 * (X_n + X_s))} \quad (1)$$

With given system parameters (Ki = 300; Xn = 0.0667 pu/200 MVA; Xs = 0.03 pu/200 MVA), Tc = 0.0345 s. If you increase the regulator gain or decrease the system strength, the measurement time constant and the valve firing delay Td will no longer be negligible and you will observe an oscillatory response and eventually unstability.

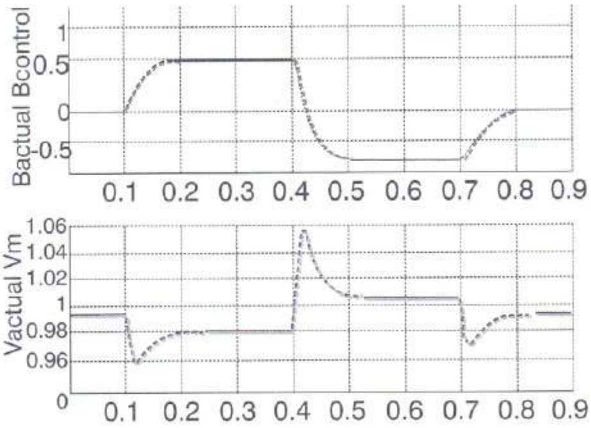


Fig. 3 showing the actual positive-sequence susceptance B1 and control signal output B of the voltage regulator. And actual system positive-sequence voltage V1 and output Vm of the SVC measurement system

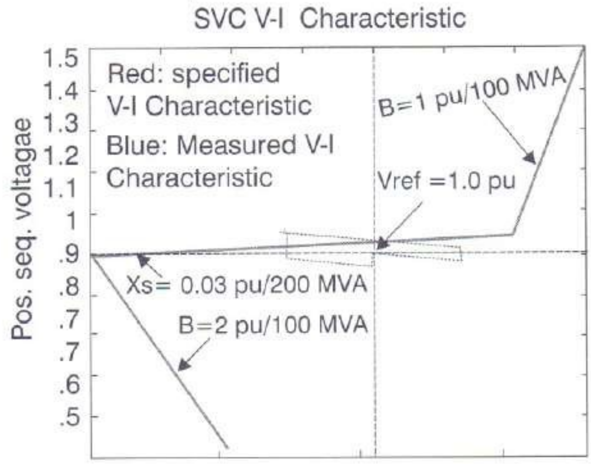


Fig. 4 showing the theoretical V-I characteristic is displayed (in red) together with the measured characteristic (in blue)

VI. Conclusions

A static var compensator (SVC) is used to regulate voltage on a power system. The operating principle and theoretical analysis of SVC is studied and simulated. Dynamic response of the SVC and steady-state V-I characteristic are plotted as shown in fig 3 and fig

4. The benefits of SVC are

- Increased Power Transfer Capability
- Additional Flexibility in Grid Operation
- Improved Grid Voltage Stability
- Improved Grid Voltage Control
- Improved Power Factor

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