VOLTAGE CONTROL AND DYNAMIC PERFORMANCE OF POWER TRANSMISSION SYSTEM USING STATCOM AND ITS COMPARISON WITH SVC

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ABSTRACT

This paper investigates the effects of Static Synchronous Compensator (STATCOM) on voltage stability of a power system. This paper will discuss and demonstrate how STATCOM has successfully been applied to power system for effectively regulating system voltage. One of the major reasons for installing a STATCOM is to improve dynamic voltage control and thus increase system load ability. This paper presents modeling and simulation of STATCOM in MATLAB/Simulink. In this paper A STATCOM is used to regulate voltage in a power system. When system voltage is low the STATCOM generates reactive power (STATCOM capacitive). When system voltage is high it absorbs reactive power (STATCOM inductive). The STATCOM more effectively enhance the voltage stability and increase transmission capacity in a power system. In this paper comparison is also performed between SVC and STATCOM under fault condition and it is shown that STATCOM have the ability to provide more capacitive power during a fault over SVC. It is also shown that STATCOM exhibits faster response than SVC.

KEYWORDS: *Dynamic Performance, FACTs, Matlab/Simulink,Transient Stability.*

I. INTRODUCTION

Today's changing electric power systems create a growing need for flexibility, reliability, fast response and accuracy in the fields of electric power generation, transmission, distribution and consumption. Flexible Alternating Current Transmission Systems (FACTS) are new devices emanating from recent innovative technologies that are capable of altering voltage, phase angle and/or impedance at particular points in power systems. Their fast response offers a high potential for power system stability enhancement apart from steady state flow control. Among the FACTS controllers, STATCOM provides fast acting dynamic reactive compensation for voltage support during contingency events which would otherwise depress the voltage for a significant length of time. In emerging electric power systems, increased transactions often lead to the situations where the system no longer remains in secure operating region. The flexible AC transmission system (FACTS) controllers can play an important role in the power system security enhancement. However, due to high capital investment, it is necessary to locate these controllers optimally in the power system. FACTS devices can regulate the active and reactive power control as well as adaptive to voltage-magnitude control simultaneously because of their flexibility and fast. In this paper Control System Block diagram and V-I Characteristics of STATCOM are described. STATCOM is modeled in MATLAB/ Simulink and simulation results are shown and discussed.

II. STATIC SYNCHRONOUS COMPENSATOR (STATCOM)

The Static Synchronous Compensator (STATCOM) is a shunt device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability on power grids. The STATCOM regulates voltage at its terminal by controlling the amount of reactive power injected into or absorbed from the power system. When system voltage is low, the STATCOM generates reactive power (STATCOM capacitive). When system voltage is high, it absorbs reactive power (STATCOM inductive).

III. CONTROL SYSTEM BLOCK DIAGRAM OF STATCOM

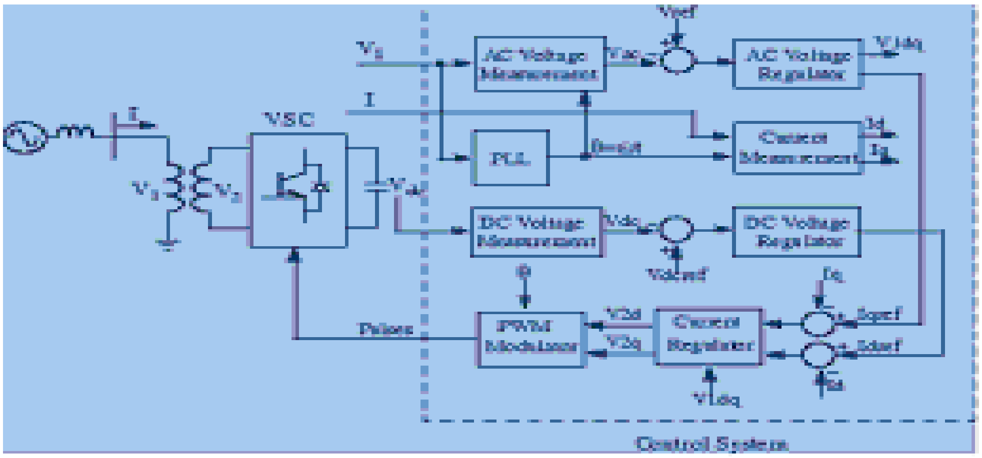

Fig 1: Block Diagram of STATCOM

Control System Block Diagram of STATCOM
The control system consists of:

- A phase-locked loop (PLL) which synchronizes on the positive-sequence component of the three-phase primary voltage V1. The output of the PLL (angle Θ=ωt) is used to compute the direct-axis and quadrature-axis components of the AC three-phase voltage and currents (labeled as Vd, Vq or Id, Iq on the diagram).
- Measurement systems measuring the d and q components of AC positive-sequence voltage and currents to be controlled as well as the DC voltage Vdc.
- An outer regulation loop consisting of an AC voltage regulator and a DC voltage regulator. The output of the AC voltage regulator is the reference current Iqref for the current regulator (Iq = current in quadrature with voltage which controls reactive power flow). The output of the DC voltage regulator is the reference current Idref for the current regulator (Id = current in phase with voltage which controls active power flow).
- An inner current regulation loop consisting of a current regulator. The current regulator controls the magnitude and phase of the voltage generated by the PWM converter (V2d V2q) from the Idref and Iqref reference currents produced respectively by the DC voltage regulator and the AC voltage regulator (in voltage control mode). The current regulator is assisted by a feed forward type regulator which predicts the V2 voltage output (V2d V2q) from the V1 measurement (V1d V1q) and the transformer leakage reactance.

IV. V-I CHARACTERISTICS OF STATCOM

As long as the reactive current stays within the minimum and minimum current values (-Imax, Imax) imposed by the converter rating, the voltage is regulated at the reference voltage Vref. However, a voltage droop is normally used (usually between 1% and 4% at maximum reactive power output), and the V-I characteristic has the slope indicated in the figure. In the voltage regulation mode, the V-I characteristic is described by the following equation:

$$V=V_{ref} + X_s I$$

Where
V : Positive Sequence Voltage (pu)
I : Reactive Current (I>0 indicates an Inductive Current)
Xs: Slope or Droop Reactance

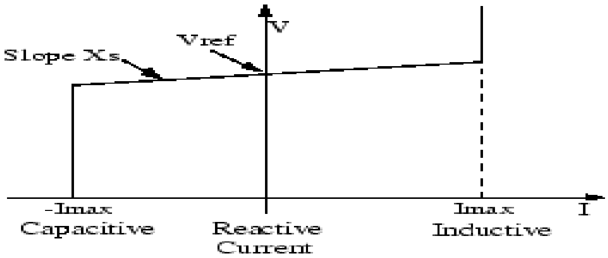

Fig 2: V-I Characteristics of STATCOM

V. MODELLING OF STATCOM / SVC

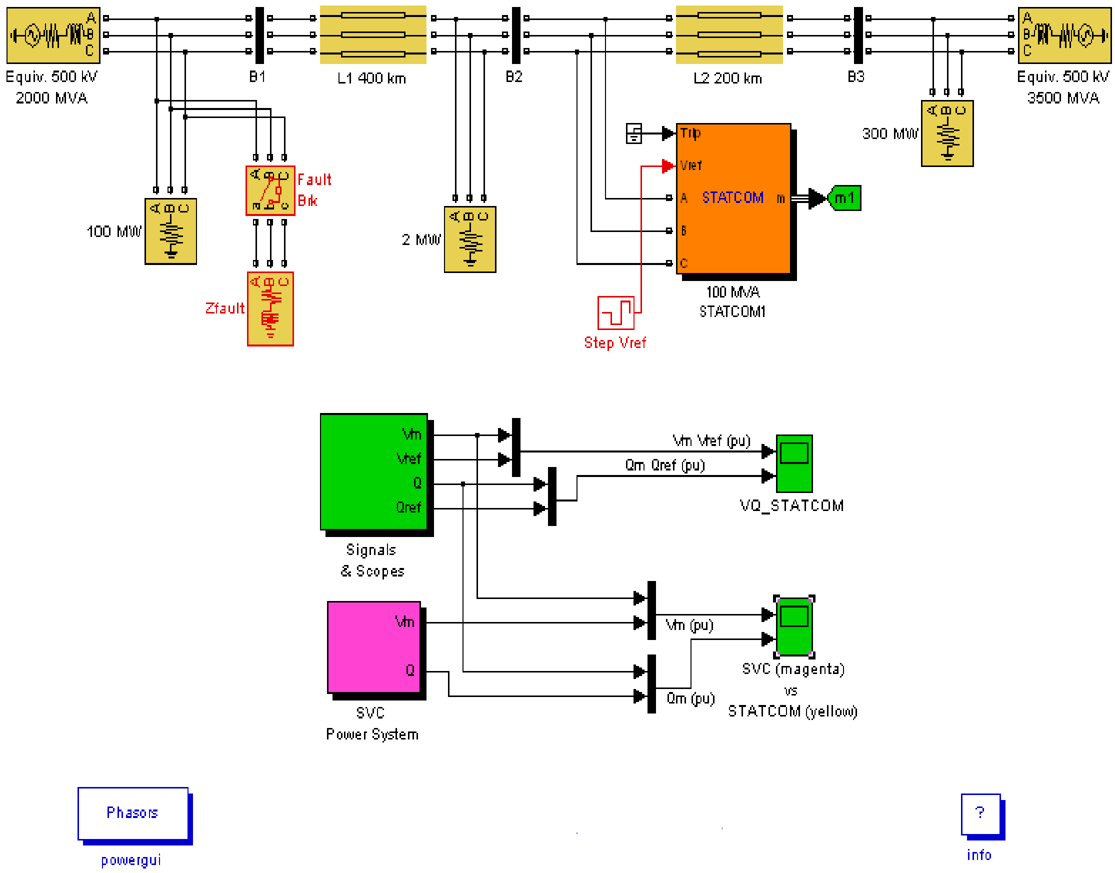

Fig 3: STATCOM / SVC on a 500 KV Transmission Line

The power grid consists of two 500-kV equivalents (respectively 2000 MVA and 3500 MVA) connected by a 600-km transmission line. In this paper STATCOM has a rating of +/- 100MVA."Droop" parameter should be set to 0.03 and the "Vac Regulator Gains" to 5 (Proportional gain Kp) and 1000 (Integral gain Ki). "Step Vref" block (the Red timer block connected to the "Vref" input of the STATCOM) should be programmed to modify the reference voltage Vref as follows: Initially Vref is set to 1 pu; at t=0.2 s, Vref is decreased to 0.97 pu; then at t=0.4 s, Vref is increased to 1.03; and finally at 0.6 s, Vref is set back to 1 pu. Here fault breaker at bus B1will not operate during the simulation.

VI. COMPARISON OF STATCOM AND SVC

In an another experiment for comparison of STATCOM model with a SVC model having the same rating (+/- 100 MVA) SVC is connected to a power grid similar to the power grid on which our STATCOM is connected and disabling the "Step Vref" block by multiplying the time vector by 100 then program the fault breaker by selecting the parameters "Switching of phase A, B and C" and verify that the breaker is programmed.

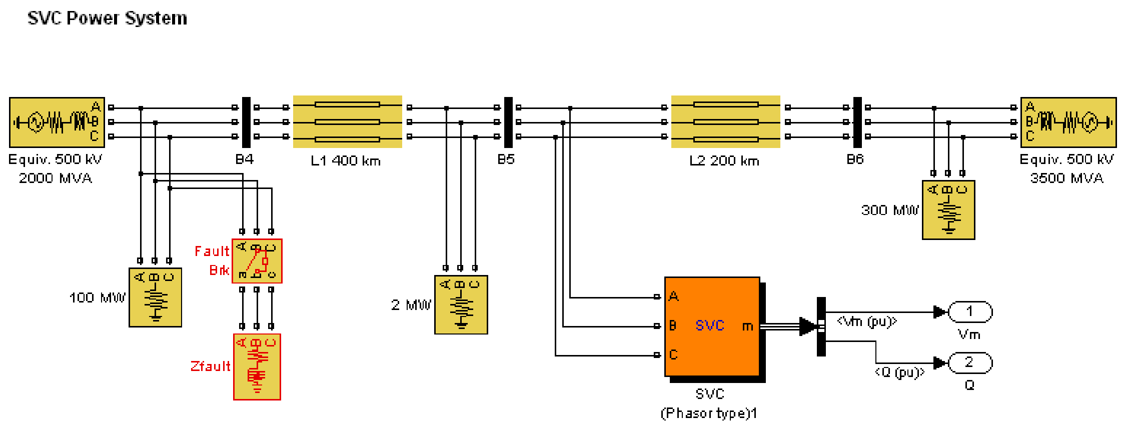

Fig 4: SVC Power System

VII. SIMULATION RESULTS AND DISCUSSIONS

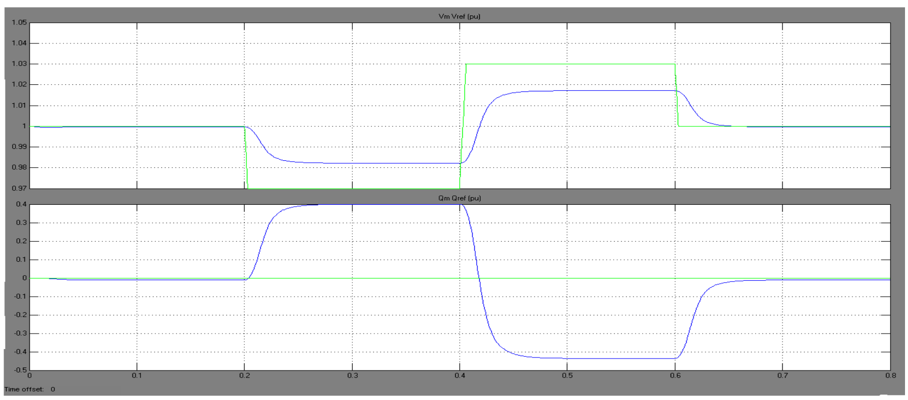

Fig 5: STATCOM Dynamic Response

The first graph displays the Vref signal (green trace) along with the measured positive-sequence voltage Vm at the STATCOM bus (violet trace). The second graph displays the reactive power Qm (violet trace) absorbed (positive value) or generated (negative value) by the STATCOM. The signal Qref (green trace) is not relevant to this simulation.

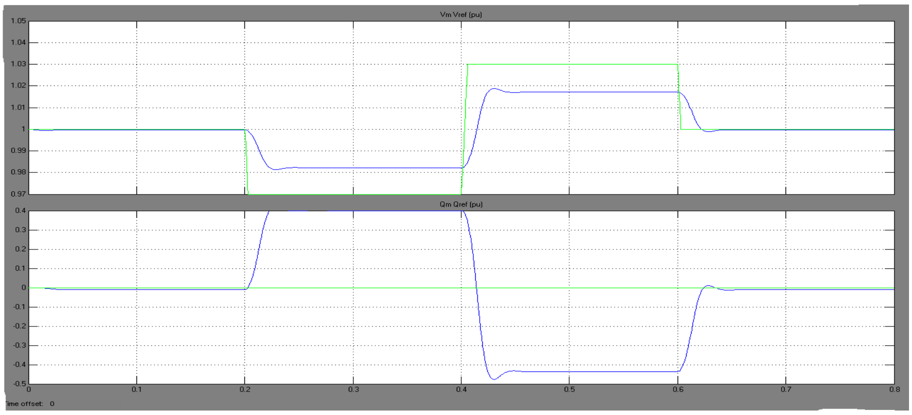

Fig 6: STATCOM Faster Dynamic Response

To check the impact of the regulator gains, the two gains of the Vac Regulator Gains are multiplied by two and simulation is rerun. A much faster response with a small overshoot is observed as shown in Fig. 6.

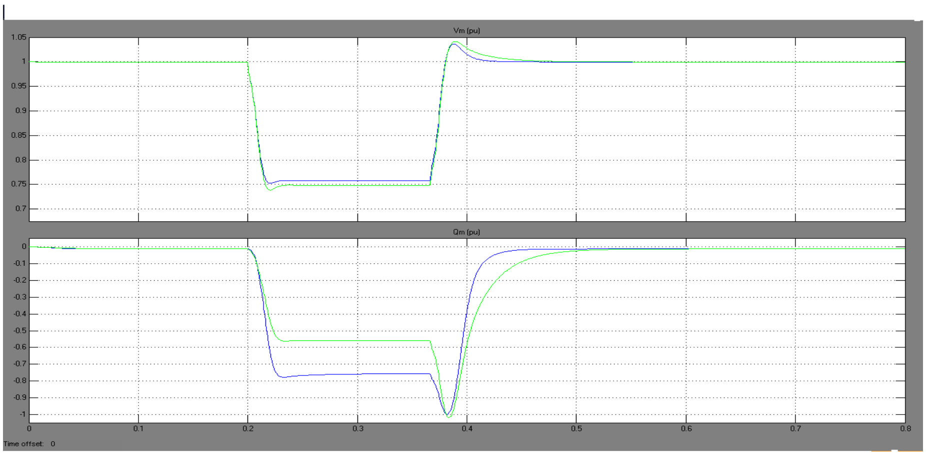

Fig 7: Comparison between Vm and Qm of SVC and STATCOM

For comparison of STATCOM model with a SVC model SVC is connected to a power grid similar to the power grid on which STATCOM is connected and disabling the "Step Vref" block by multiplying the time vector by 100 then program the fault breaker by selecting the parameters "Switching of phase A, B and C". Now simulation is run again at the "SVC vs STATCOM" scope graphs shown in Fig. 7 are observed. The first graph displays the measured voltage Vm on both systems (green trace for the SVC). The second graph displays the measured reactive power Qm generated by the SVC (green trace) and the STATCOM (violet trace). During the 10-cycle fault, a key difference between the SVC and the STATCOM can be observed. The reactive power generated by the SVC is -0.58 pu and the reactive power generated by the STATCOM is -0.79 pu.

VIII. CONCLUSION

Hence it is concluded that the maximum capacitive power generated by a SVC is proportional to the square of the system voltage (constant susceptance) while the maximum capacitive power generated by a STATCOM decreases linearly with voltage decrease (constant current). This ability to provide more capacitive power during a fault is one important advantage of the STATCOM over the SVC. In addition, the STATCOM will normally exhibit a faster response than the SVC because with the voltage-sourced converter, the STATCOM has no delay associated with the thyristor firing (in the order of 4 ms for a SVC). So STATCOM provides fast acting dynamic reactive compensation for voltage support during contingency events which would otherwise depress the voltage for a significant length of time. So In this paper it is successfully demonstrated that how STATCOM has successfully been applied to power system for effectively regulating system voltage.

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