Application of Fact Devices for Voltage Stability in a Power System

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***Abstract*— Paper narrates an application of STATCOM and SVC, for effectively regulating system voltage. Also this paper shows the effect of static synchronous compensator (STATCOM) and SVC on the voltage stability of power system. Main objective of this paper is to improve dynamic voltage control and thus increasing system load ability. With the increasing use of nonlinear loads in today's word, it has been essential requirement to have compensator that can efficiently provide compensation with increasing or decreasing load demand. The STATCOM is used to regulate voltage in power system by generating or absorbing reactive power. 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).This paper present modelling and simulation of STATCOM and SVC in MATLAB/ Simulink for dynamic voltage control.**

Keywords*— Dynamic performance, FACTs Controller MATLAB/Simulink, Transient stability.

I. Introduction

THE STATCOM is basically a shunt connected switching converter type VAR generator. This switching converter can be Voltage source converter or current source converter. Generally voltage source converter is being used but this model uses a current source inverter. This system has the basic block diagram of a STATCOM. Rapidly operating static var compensator (SVC) can continuously provide the reactive power required to control dynamic voltage oscillation under various system conditions thereby improve the power system transmission and distribution stability.

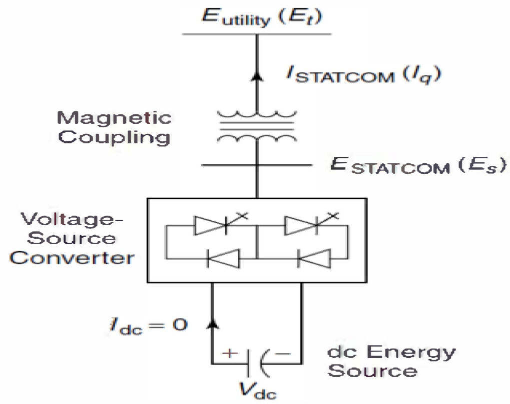
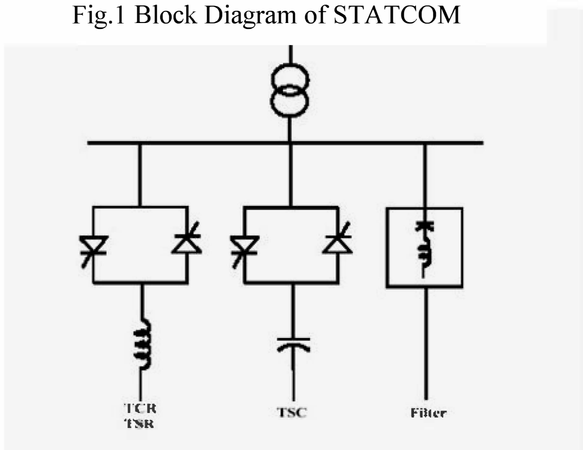


Fig.1 Block Diagram of STATCOM



The switching converter uses self-commutating switches like GTO, IGBT. The switching converter type have several advantages over variable impedance type VAR generators (TCR, TSC, SVC) like faster response, requires less space, re-locatable and modular. It can be interfaced with real power sources like battery etc. The most important feature is that it can provide better performance under low voltage condition as the reactive can be maintained constant.

II. CONTROL SYSTEM BLOCK DIAGRAM OF STATCOM AND SVC

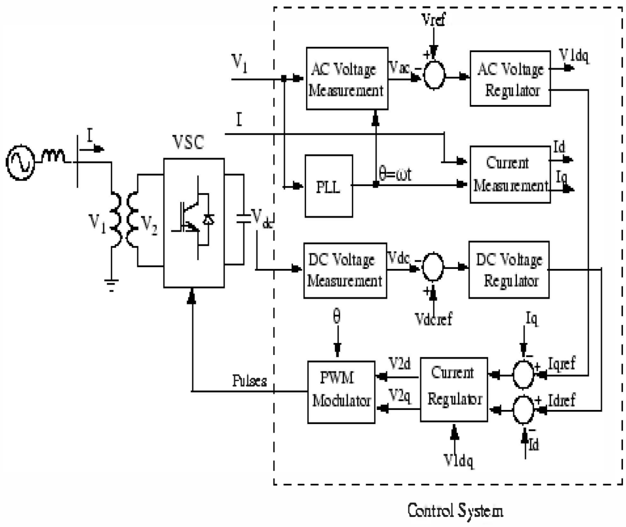


Fig.2 Control Block Diagram of STATCOM

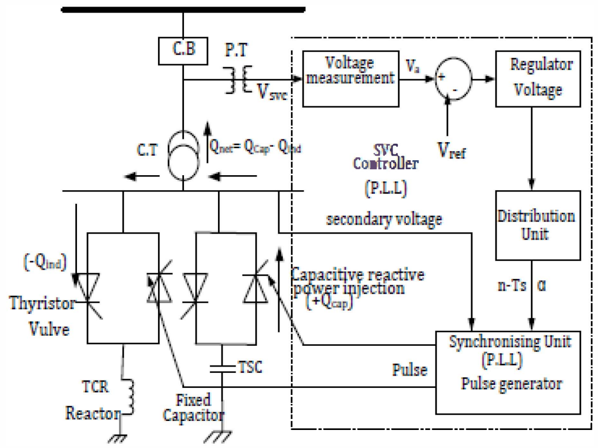


Fig. 3 Control System Block Diagram of SVC

The control system consist of

1) Phase lock loop-PLL synchronize positive sequence component of the three phase primary voltage V1. The output of the PLL (angle ϴ=wt) is used to compute direct axis and quadrature axis components of AC 3φ voltage and current (V_d, V_q, & I_d, I_q).

2) The AC and DC measurement system measures the d & q components of AC positive sequence voltage and current as well as DC voltage V_{dc} to be controlled

3) The outer regulation loop consists of AC voltage regulator and DC voltage regulator. The output of AC voltage regulator is the reference current I_{qref} and is given to current regulator. Where I_q is the current in quadrature with voltage which control reactive power flow. The output of DC voltage regulator is reference I_{dref} and is given to current regulator. I_d is the current in phase with voltage which control active power flow.

4) From I_{dref} and I_{qref} reference current produced respectively by DC voltage regulator and AC voltage regulator given to current regulator at control magnitude and phase of voltage generated by PWM converter (V_{2d}, V2q) and gives the proper gate pulse to V_{sc} for further operation of voltage regulator.

5) SVC control system consists a measurement system measuring the positive-sequence voltage to be controlled. A Fourier-based measurement system using a one-cycle running average is used.

6) A voltage regulator that uses the voltage error (difference between the measured voltage V_m and the reference voltage V_{ref}) to determine the SVC susceptance B needed to keep the system voltage constant.

7) A distribution unit that determines the TSCs (and eventually TSRs) that must be switched in and out, and computes the firing angle α of TCRs.

8) A synchronizing system using a phase-locked loop (PLL) synchronized on the secondary voltages and a pulse generator that send appropriate pulses to the thyristors.

III. V-I CHARACTERISTIC OF STATCOM AND SVC

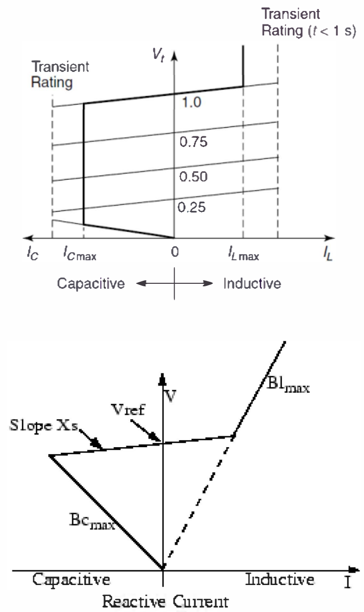


Fig. 4 V-I Characteristic of STATCOM and SVC

The typical VI characteristic of STATCOM is shown in fig. This shows that the STATCOM can provide full capacitive reactive power at any system voltage. Even as low as 0.15 pu fig. shows that the STATCOM has increase transient rating in both capacitive and inductive region and the transient rating of STATCOM is limited by maximum allowable junction temperature of the converter switches.

The SVC can be operated in two different modes:

A) In voltage regulation mode (the voltage is regulated with-in limits as explained below).

b) In VAR control mode (the SVC susceptance is kept constant).

From V-I curve of SVC

$V=V_{ref}+X_s.I$, in regulation range

$(-B_{cmax}<B<B_{cmax})$

$V=I/B_{cmax}$,:SVC is fully Capacitive($B=B_{cmax}$)

$V=1/B_{lmax}$, : SVC is fully inductive($B=B_{lmax}$)

IV. SIMULATION MODEL

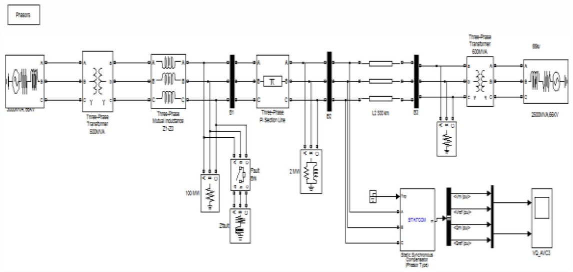


Fig. 5 STATCOM on a 500KV Transmission Line

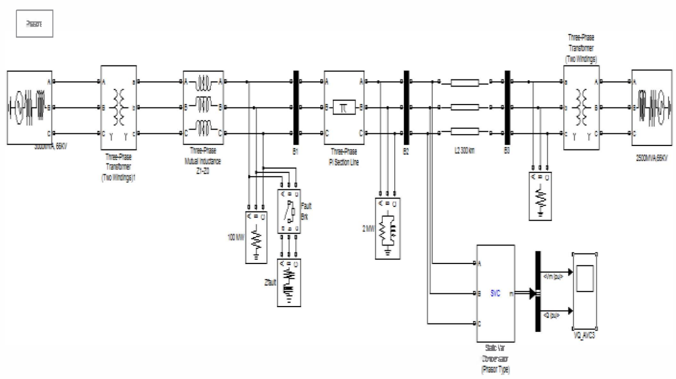


Fig. 6 SVC on a 500KV Transmission Line

STATCOM and SVC are connected approximately middle point of the transmission line. In that test model two generators are connected both end side. The three phase mutual inductance connected in series with the first generator. B1, B2 and B3 are used for measurement of voltage and current of transmission line. We are considering in test model the three phase PI section line and three phase distributed parameter line. The three loads are connecting parallel with transmission line that is 100MW, 2MW, 300MW. We are also connected fault impedance for creating fault in transmission line by manually. After creating a fault the disturbances in transmission line can be compensated by STATCOM and SVC.

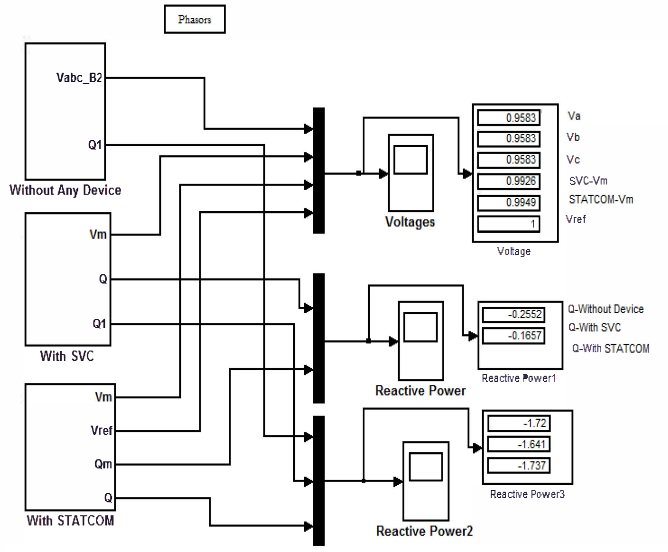


Fig. 7 Common model of transmission line

Above figure shows the MATLAB simulation model of transmission line with STATCOM, SVC ,and without any compensator whose output graphs are displayed on common display of voltages and reactive power scopes to compare the performance of simple transmission line without any compensator, STATCOM and SVC.

V. RESULTS

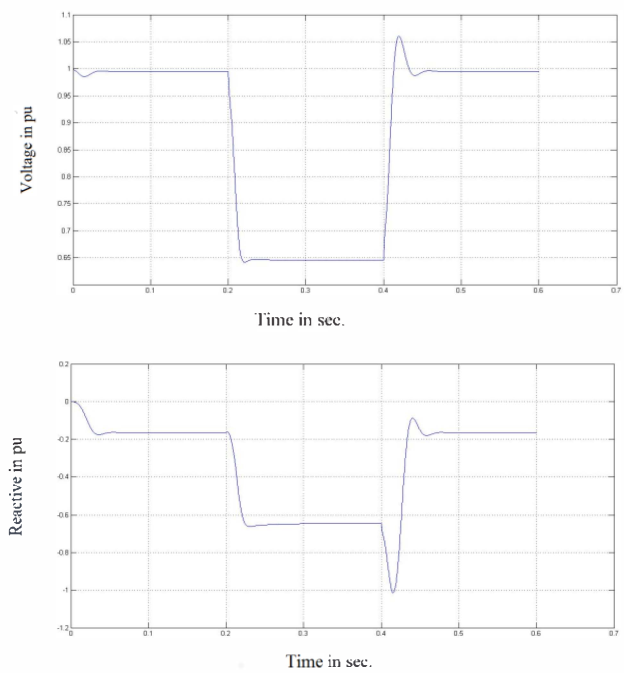


Fig. 8 STATCOM Dynamic Response

The first graph displays the measured positive-sequence voltage Vm at the STATCOM bus .The second graph displays the reactive power absorbed or generated by the STATCOM.

At the initial stage transmission line is inductive. Because of the inductive load transmission line voltage decreases of the desire value, to maintain the desire voltage level STATCOM act as capacitive (0-0.2 sec.).

At the instant 0.2 Z-fault occur and voltage falls down (02-0.4 sec.) at that time STATCOM is act as more capacitive and goes more negative to regulate voltage.

At the instant 0.4 fault is suddenly remove at that time STATCOM take one overshoot and comes at desire level same as the before fault occur.

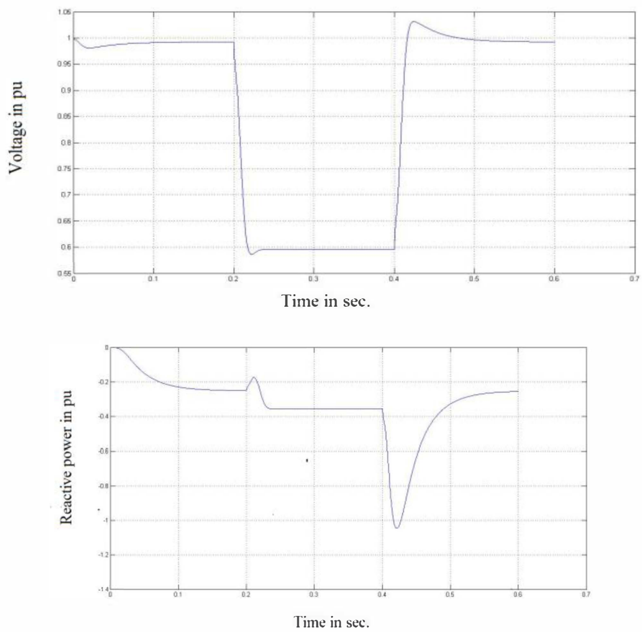


Fig. 9 SVC Dynamic Response

The first graph displays measured positive-sequence voltage Vm. The second graph displays the reactive power Qm absorbed or generated by the SVC.

At the initial stage transmission line is inductive. Because of the inductive load transmission line voltage decreases of the desire value, to maintain the desire voltage level SVC act as capacitive (0-0.2 sec.).

At the instant 0.2 Z-fault occur and voltage falls down (02-0.4 sec.) at that time SVC is act as more capacitive and goes more negative to regulate voltage.

At the instant 0.4 fault is suddenly remove at that time SVC take one overshoot but it requires more time to settle down the desire level.

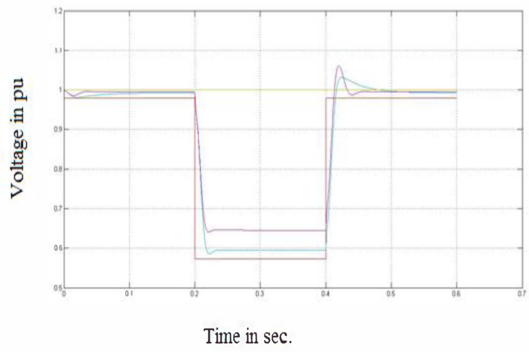


Fig. 10 Voltages of common model

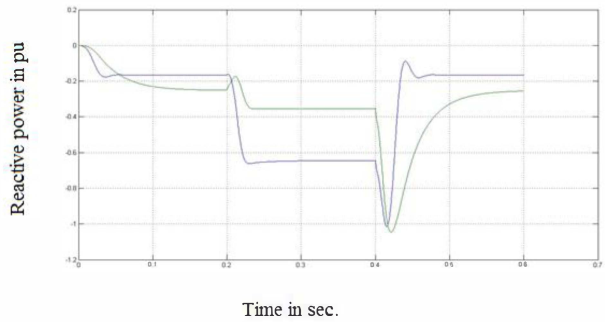


Fig. 11 Reactive Power of STATCOM & SVC

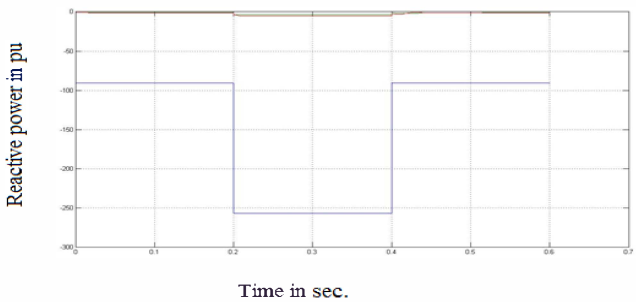


Fig. 12 Reactive Power of Transmission Line

Graph 9 Represents system voltage without device. From graph it is clear that STATCOM has faster response to reach desired voltage level during faults than SVC. The sky blue line represents transmission line voltage without any device connected to the transmission line. Fig .10 shows the reactive power injected and absorbed by the STATCOM and SVC. It shows that at point 0.2 sec the circuit breaker is closed due to fault sudden voltage drop occur in the system and STATCOM and SVC starts to inject reactive power to regains the system reference voltage level.

It results that STATCOM inject more reactive power than SVC hence it has faster response than SVC. Fig 11 shows the reactive power of transmission line without any device.

VI. CONCLUSION

In this paper the power system with various loads connected at different buses by making a Simulink model in MATLAB. In this paper it is shown that how STATCOM has successfully been applied to power system for effectively regulating system voltage. When system voltage is low the STATCOM generates reactive power (STATCOM capacitive). When system voltage is high it absorbs reactive power (STATCOM inductive). The usefulness of SVC has been studied in improving the transient stability of the above model. The transient stability of the system is highly affected by SVC. Thus it can be concluded that the transient stability of power system with different loads at different buses improves by using SVC.

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