

Exploring SVC and STATCOM: Unveiling the Secrets behind Power System Reliability

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ABSTRACT

Modern power systems' transmission networks are under increasing strain as a result of rising demand and limits on the construction of additional lines. The risk of losing stability after a disruption is one result of such a strained system. In order to better utilize a transmission network's current facilities while maintaining the appropriate stability margin, flexible ac transmission system (FACTS) devices are shown to be equally effective. In order to control voltage and power flow in electric power transmission systems, Flexible AC Transmission System (FACTS) controllers, like Static Synchronous Compensator (STATCOM) and Static VAR Compensator (SVC), use the most recent power electronic switching technology. These devices also play a significant role as a stability aid for and transient disturbances in an interconnected power systems. Examine SVC and STATCOM behavior in the electric power system is shown. Its foundation is analytical and simulation analysis and its recommendations may be applied to the power sector.

Keyword: SVS, STATCOM, voltage regulation, transient stability

INTRODUCTION

With hundreds of producing stations and load centers connected by power transmission lines, today's power systems are intricate networks. These days owing to capital investment, it is difficult to utilize the current transmission system assets. Right-of-way problems, environmental legislation the price of building additional lines and deregulation measures.

The environment in which the power system functions is always changing; this includes changes in loads, generator outputs, topology, and important operational parameters. The stability of the system during a transitory disturbance depends on the type of disturbance and the

initial operating conditions. The disruption might be minor or severe. The system adapts to the shifting conditions as little disruptions in the form of load fluctuations occur continuously.[1]

Under these circumstances, the system must be permitted to successfully run and satisfy the load demand. It must also be able to withstand several severe disruptions, including a transmission line short-circuit or the loss of a sizable amount of power.

For better use of already available transmission facilities, the Flexible AC Transmission Systems (FACTS) Controller, based on the quick

advancement of power electronic technology, has been proposed recently. Shunt-connected static Var compensators (SVCs) are widely employed in transmission networks to control the AC voltage. Power electrical devices like the thyristor switched capacitor and the thyristor controlled reactor (TCR). [2]

A further crucial FACTS gadget, Static Synchronous Compensation (STATCOM), which has also been widely employed in power systems, is more efficient in enhancing the transient stability of the power systems.

The use of FACTS devices in power systems improves the system's performance in various ways. By employing these devices and properly controlling them, voltage stability, voltage regulation, and power system stability and damping may all be enhanced.

FACTS devices come in a variety of shapes and sizes, and some of them are linked to a line in series while others are in shunt or a mix of series and shunt. The FACTS technology is ideally a collection of controllers that may be used separately or in conjunction with one another to control one or more devices.

It is more effective to improve the transient stability of the power systems by using Static Synchronous Compensation (STATCOM), which has also been widely used in power systems.

The performance of power systems is enhanced in a number of ways by the employment of FACTS devices. Voltage stability, voltage regulation, and power system stability and damping may all be improved by using these devices and

managing them effectively. Different FACTS devices have different sizes and forms, and some of them are connected to a line in series while others are in shunt or a combination of series and shunt. The ideal FACTS technology would consist of a number of controllers that could be used singly or in combination to regulate one or more devices.[3]

SVC OPERATING PRINCIPLE AND MODELLING

The TSC-TCR type compensators are coupled in parallel to form the static Var compensator, which is used to dynamically correct for reactive power in power transmission networks. Figure 3(a) depicts the functional control strategy for SVC.

The control system serves three main purposes:

1. Calculating the necessary inductive current to counteract the excess capacitive current and deciding how many TSC branches should be activated to approximate the requisite capacitive output current.
2. Manages the TSC branches' switching.
3. Adjusts the firing delay angle to change the current in the TCR.

The SVC is made up of n parallel-connected TSC banks and one TCR branch. TCR's rating is set at $1/n$ of the overall SVC rating. The TCR is controlled continuously, whereas the capacitors are swapped in discrete stages.

The harmonic generation is also modest since the TCR is very tiny. To filter harmonic currents in the transmission system, the TSC branches are tuned to various harmonic frequencies using a series reactor.[4]

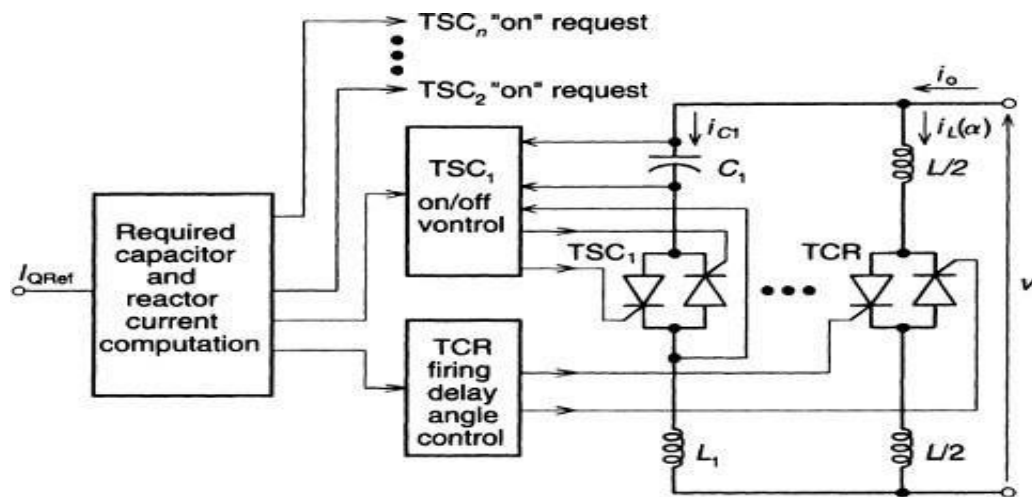


Fig. 1: Control Scheme for SVC.

The fundamental SVC model proposed by the IEEE Special Stability Controls Working Group is shown in Figure 2(a).

As seen in Figure 2(b), the voltage regulator in this fundamental model is of the integral plus proportional type.

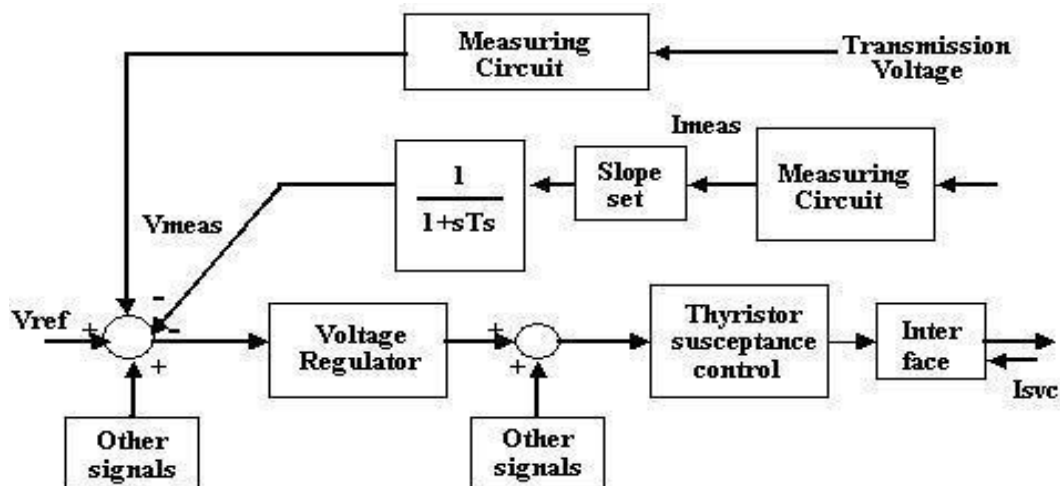


Fig. 2(a): Basic Model – 2 of SVC.

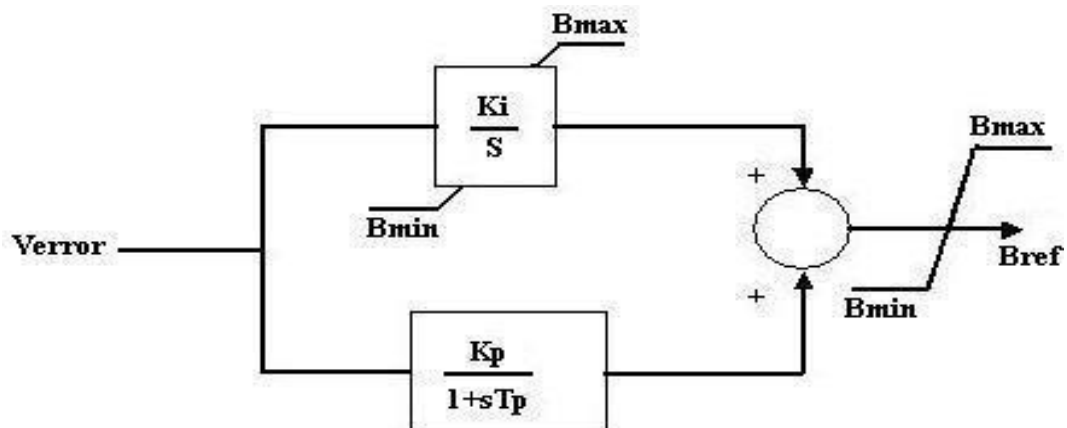


Fig. 2(b): Voltage regulator model for Basic Model – 2 of SVC.

STATCOM OPERATING PRINCIPLE AND MODELLING

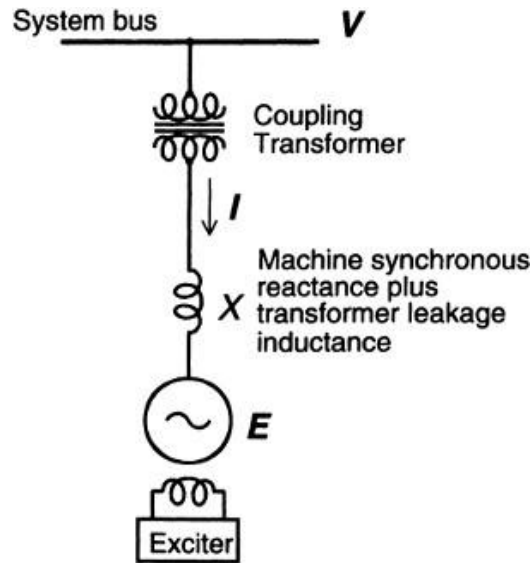


Fig. 3: Reactive power compensation Synchronous condenser.

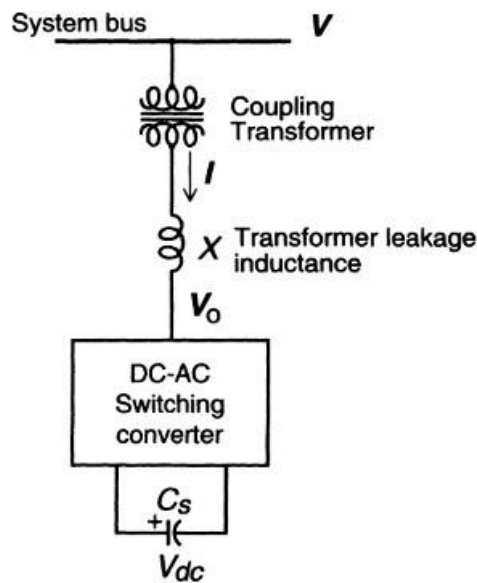


Fig. 4: Reactive power for power generation by STATCOM Using VSC.

According to Figure 3, the fundamental principles of reactive power production by voltage source converters are identical to those of typical rotating synchronous machines. I drew a reactive current from the

The magnitude of the system bus voltage V , internal voltage E , and total reactance X (synchronous machine reactance plus transformer leakage reactance plus system short circuit reactance) are used to calculate the synchronous condenser.

$$I = \frac{V - E}{X}$$

The equivalent reactive power exchanged, Q , is written as follows:

$$Q = \frac{E1 - V}{X} * V^2$$

Therefore, the reactive power flow may be adjusted by adjusting the machine's excitation and, in turn, the internal voltage E in relation to the system voltage's amplitude V . Leading current occurs when E is raised above V (over stimulated), which makes the machine seem to the AC system as a capacitor.

Lagging current is produced when E is reduced below V (under stimulated), which causes the machine to be seen as a reactor (inductor) by the AC system. Therefore, the necessary reactive power may be maintained by adjusting the machine's excitation.

Figure 4 depicts the fundamental voltage sourced converter architecture for the generation of reactive power as a single line diagram. From the DC input voltage source, which is given by the charged capacitor C_s , the converter generates a set of adjustable three phase output voltages at the frequency of the AC system.

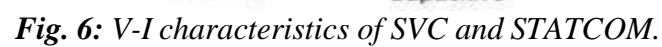
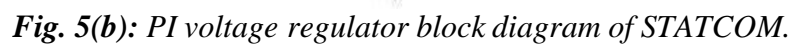
The output voltage is connected to the appropriate AC system voltage using a tiny tie reactance of 0.1 to 0.15 pu, which is really given by the coupling transformer's leakage inductance. The reactive power exchange between the converter and the AC system may be managed similarly to a spinning synchronous machine by adjusting the amplitude of the output voltages generated.

In other words, if the output voltage's amplitude is greater than the voltage of the AC system, current will flow via the converter's tie line reactance and into the AC system, causing the converter to

provide reactive power (capacitive) for the AC system. Reactive current flows from the AC system to the converter when the output voltage's amplitude is reduced below that of the AC system, which causes the converter to inductively absorb reactive power. Reactive power exchange is zero if the output voltage's amplitude is equal to the voltage of the AC system. The true power supplied by the DC source must be zero because the converter only provides reactive output power. Alternatively put The converter then only links the three AC terminals together in a manner that allows the reactive output currents to easily flow between them. Figure 5(a) illustrates how the d-q decoupled current control approach is put into practice. The STATCOM control system is described as follows.

At the point of the STATCOM connection, a phase-locked loop (PLL) is employed to synchronize the STATCOM current with the bus voltage. An AC voltage regulator: it supplies the system with the reference reactive current I_{qref} needed to keep the bus voltage constant or within a predetermined range.

An example of a DC voltage regulator is one that provides the reference active current I_{dref} to keep the capacitor voltage constant or within a certain range. The inner current regulator regulates the reactive current needed by the STATCOM to provide or absorb power as per the reference value provided by the AC and DC voltage regulators. It does this by controlling the amplitude and phase of the voltage created by the PWM converter of the STATCOM. Figure.5b depicts the Simulink phasor model.[5]



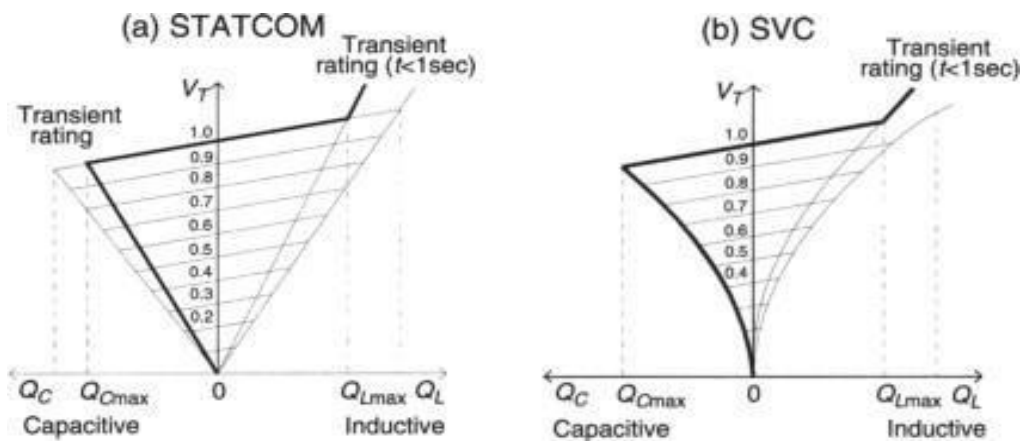


Fig. 7: V-Q characteristics of SVC and STATCOM.

IEEE 5 BUS SIMULATION IN MATLAB/SIMULINK WITH FACTS DEVICE

Case (i): SVC Connected at Bus 5 in IEEE 5 Bus System

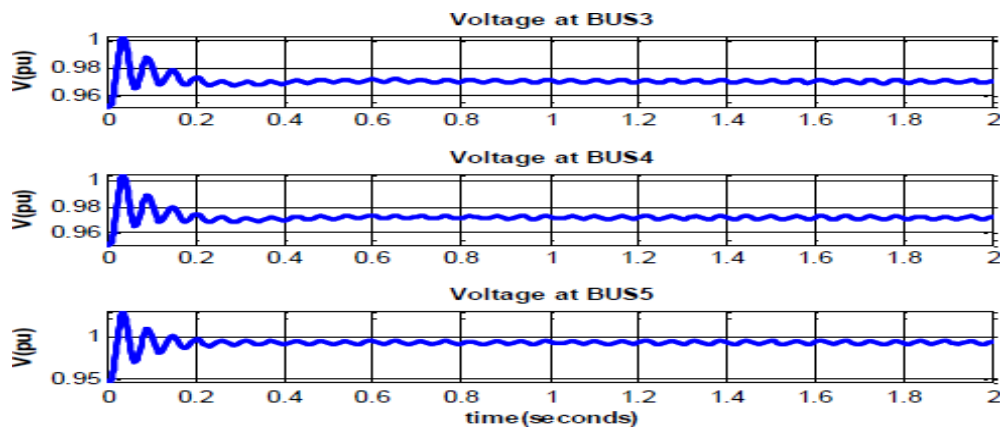


Fig. 8: SVC bus 3, 4, and 5 voltage waveforms.

Case (ii) STATCOM connected at Bus 5 in IEEE 5 bus systems

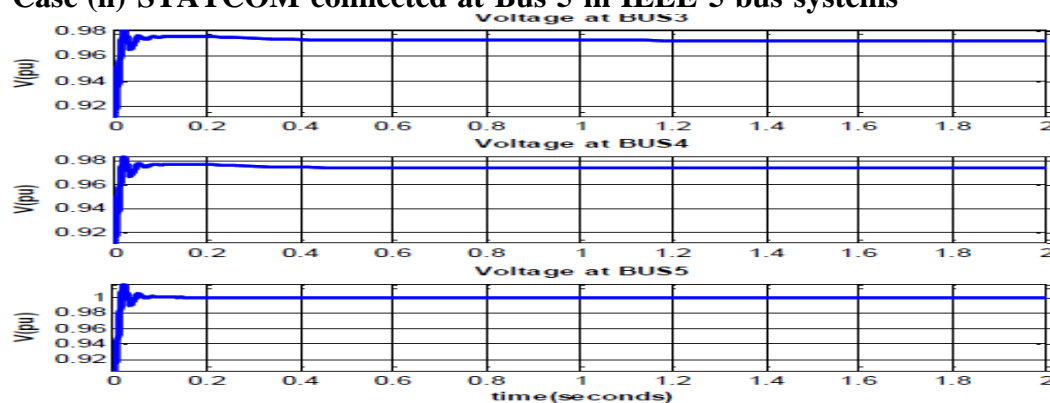


Fig. 9: STATCOM bus 3, 4, and 5 voltage waveforms.

| Serial No | Load at 5 th Bus | |
|----------------|-----------------------------|--------------|
| | With SVC | With STATCOM |
| V ₃ | 0.97 | 0.98 |
| V ₄ | 0.97 | 0.98 |
| V ₅ | 0.9952 | 1.0 |

The outcomes are tallied as displayed in the table it offers. The magnitude and reaction time of STATCOM are superior to SVC, and STATCOM offers higher voltage stability under dynamic load changes.

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CONCLUSION

Based on a comparison of the STATCOM and the SVC and a number of factors, it is determined that a STATCOM is preferable to the SVC and other compensating devices. The STATCOM essentially circulates electricity with the associated network rather than obtaining reactive power directly from the energy storage components. Consequently, compared to the SVC, the reactive components employed in the STATCOM are substantially less.

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