Comparison Between Statcom And Svc Fact Device Using Matlab Simulation Software

Govind Prasad, Prof. A. K. Sharma

Department of electrical engineering, Jabalpur Engineering College, College in Jabalpur, Madhya Pradesh

Abstract

The development of the modern power system has led to an increasing complexity in the study of power systems, and also presents new challenges to power system stability, and in particular, to the aspects of transient stability and small-signal stability. Transient stability control plays a significant role in ensuring the stable operation of power systems in the event of large disturbances and faults, and is thus a significant area of research. This paper investigates comparison of SVC and STACOM performance for the transient stability improvement of the two area multi machine power system. The improvement of transient stability of a two-area multi-machine power system, using SVC (Static VAR Compensator) STATCOM (Static Synchronous Compensator) which is an effective FACTS (Flexible AC Transmission System) device capable of controlling the active and reactive power flows in a transmission line by controlling appropriately parameters. Simulations are carried out in Matlab/Simulink environment for the two-area multi-machine power system model with SVC & STATCOM to analyze the effects of SVC & STATCOM on transient stability performance of the system. The performance of SVC & STATCOM is compared from each other. In comparative result STACOM gives the better result than SVC .So for the improvement of transient stability STATCOM is better than SVC. The simulation results demonstrate the effectiveness and robustness of the proposed STATCOM & SVC on transient stability improvement of the system.

Keywords: Power quality, D-STATCOM, Voltage Sag, Voltage Source Converter (VSC), Energy storage system.

I. INTRODUCTION

Modern power system is a complex network comprising of numerous generators, transmission lines, variety of loads and transformers. As a consequence of increasing power demand, some transmission lines are more loaded than was planned when they were built. With the increased loading of long transmission lines, the problem of transient stability after a major fault can become a transmission limiting factor [1]. Now power engineers are much more concerned about transient stability problem due to blackout in northeast United States, Scandinavia, England and Italy. Transient stability refers to the capability of a system to maintain synchronous operation in the event of large disturbances such as multi-phase short-circuit faults or switching of lines [2].

II. DIFFERENT TYPES OF POWER QUALITY ISSUES

Perfect power quality means the nature of voltage is continuous and almost purely sinusoidal with constant amplitude and frequency. The quality of the power can be expressed in the terms of the physical characteristics and properties of the electricity. Some of these describes as follow:-

- Voltage stability
- Frequency stability
- Electromagnetic interference effects
- Phase balance

III. RESEARCH MOTIVATION

A linear optimal controller is designed to implement multiple variable series compensations in transmission networks of interconnected power systems. The proposed controller was utilised to damp interarea oscillations and improve power system damping.[1]the model of a power system installed with a unified power flow controller (UPFC) was presented. A STATCOM, UPFC, and convertible static compensator were discussed [4]. The installed FACTS controllers have provided new possibilities and unprecedented flexibility aiming at maximizing the utilization of transmission assets efficiently and reliably. Mishra, et.al. presented a simple hybrid fuzzy logic proportional plus conventional integral controller for FACTS devices in a multi-machine power system [2]. This controller was designed by using an incremental fuzzy logic controller in place of a proportional term in a conventional PI controller and provides a wide variation of controller gains in a nonlinear manner. This controller is well suited to series connected FACTS devices like UPFC, TCSC and TCPST, etc., in damping multi-modal oscillations in a multi-machine environment.

IV. STATIC SYNCHRONOUS COMPENSATOR

Static Synchronous Compensator (STATCOM) is a voltage source converter based FACTS controller. It is a shunt controller mainly used to regulate voltage by generating/absorbing reactive power. STATCOM has no long term energy support in the DC Side and cannot exchange real power with the ac system ; however it can exchange reactive power. The reactive power is varied by varying the magnitude of the converter output voltage. A small phase difference exists between the converter output voltage and STATCOM bus voltage so that real power is drawn from the lines to compensate for the losses. STATCOMs are employed at distribution and transmission levels – though for different purposes.

A FACTS (Flexible AC Transmission Systems) STATCOM (Static Synchronous Compensator) device is a power electronics-based system used in electrical power networks to regulate and control voltage and improve the stability of the grid.

Key Functions and Features:

1. **Voltage Regulation**: A STATCOM is primarily used to maintain constant voltage levels by dynamically supplying or absorbing reactive power in the grid.

2. **Reactive Power Compensation**: It provides both inductive and capacitive reactive power, allowing the grid to balance load variations and maintain voltage stability.

3. **Faster Response**: STATCOM devices are known for their rapid response compared to traditional reactive power compensators like SVCs (Static Var Compensators).

4. **Power Quality Improvement**: They help reduce voltage fluctuations, flicker, and harmonics, improving the overall quality of the electrical supply.

5. **Stabilization of Power Systems**: STATCOM devices enhance the stability of transmission lines, especially in scenarios involving large power swings or system faults.

How It Works:

A STATCOM operates using Voltage Source Converters (VSCs), which convert a DC voltage source into an AC output. The phase angle and magnitude of this output can be adjusted to inject either leading (capacitive) or lagging (inductive) reactive power.

Overall, STATCOMs are widely used in modern power systems for grid stabilization, especially as renewable energy sources become more integrated into the grid [5-10].

V. SVC (STATIC VAR COMPENSATOR)

An SVC (Static Var Compensator) is a type of FACTS (Flexible AC Transmission Systems) device used in power systems to regulate voltage and improve power quality by providing dynamic reactive power compensation.

Key Features and Functions:

1. **Voltage Stabilization**: SVCs help maintain stable voltage levels by automatically adjusting the amount of reactive power supplied or absorbed in the grid.

2. **Reactive Power Compensation**: SVCs provide capacitive or inductive reactive power depending on the system's requirements, helping to maintain the desired voltage.

3. **Improved Power Quality**: By controlling voltage fluctuations, SVCs reduce issues like voltage sag, swell, and flicker, leading to a more stable power supply.

4. **Power Factor Improvement**: SVCs improve the power factor by supplying reactive power, reducing losses, and enhancing the efficiency of power transmission.

5. **Harmonic Filtering**: SVCs can be equipped with filters to mitigate harmonic distortions, ensuring cleaner power quality.

Components of an SVC:

- **Thyristor-Controlled Reactor (TCR)**: Absorbs reactive power by controlling the conduction angle of thyristors.

- **Thyristor-Switched Capacitor (TSC)**: Provides reactive power by switching capacitors in and out of the circuit using thyristors.

- **Harmonic Filters**: Used to filter out unwanted harmonics generated by the SVC.

How It Works:

An SVC operates by continuously monitoring the voltage level and adjusting the reactive power injected into or absorbed from the grid. By using fast-switching thyristors, SVCs provide a quick and smooth response to voltage fluctuations.

Applications:

SVCs are commonly used in transmission networks, industrial power systems, and renewable energy integration to enhance voltage stability, improve power transfer capability, and increase grid reliability.

SVCs are particularly useful in stabilizing the grid during high demand or fluctuating load conditions, making them vital in modern power systems.

VI. DEPENDENCE ON COMMON COUPLING POINT VOLTAGE OF STATCOM VS SVC

As STATCOM works as a controllable voltage source while SVC works as dynamically controllable reactance which is connected in parallel. This makes STATCOM continues to provide the maximum reactive current even at low voltage this possible for the reason that in every equilibrium condition the injected reactive power varies linearly with the voltage of the point of common coupling. STATCOM can output rated reactive current even under low system voltage, which makes it more effective in improving the transient stability of the power systems [3].By other side, for SVC there is a quadratic dependence of the reactive power injected by SVC on the voltage level at the common coupling point (PCC), the capacity of injecting reactive power will decline with the decline of the system voltage. Which means that to inject the same amount of reactive power it is required to install a SVC with a nominal capacity higher than that of a STATCOM [4].

RESPONSE TIME OF STATCOM vs SVC

During power system transient process the duration of fault is 0.1 second, which shows that the response time of the device determines directly the transient support ability of the compensation device [5]. As the SVC is made by the switching devices with TCR/TSC are half-controlled thyristor and cannot be turned off only when current zero-crossing occurs, so there is a control delay. Linked with transition time of the equipment, the response time of SVC is up to two to three cycles. Meanwhile the switching device used in STATCOM are composed of full-controlled device IGBT/GTO with high switching frequency, so control delay is almost neglected, the response time is basically determined by the inherent time constant of the device (generally only a few milliseconds). As a result , he entire response time of STATCOM is only one frequency cycle, sometimes even ups to only half frequency cycle. So we conclude that the response time of STATCOM is better than the one of SVC.

SYSTEM STABILITY ENHANCEMENT

As there is development of modern power system which led to an increase in complexity of power system and presents new challenges to power system stability such as transient stability and small signal stability. To ensure those stability the control of reactive power and active power is necessary which can be achieved by integration of FACTS Devices like STATCOM and SVC [6]. It is found that both STATCOM and SVC have good performance on reactive power compensation and improvement of system stability but comparing the effects of STACOM and SVC on transient stability performance of system, the result of comparison gives that STATCOM provides the better result than SVC. STATCOM is better than SVC for improvement of transient stability as having faster response than SVC and reactive current to be injected is independent of the system voltage which is not the case for SVC[6].The STATCOM provides superior performance than SVC for bus voltages, power measurement, and rotor angle and terminal voltages of the multi-machine system. For the multi-machine system, the best performance has been obtained by integrating FACTS devices such as SVC and STATCOM which compensate reactive power, increased transmission system reliability and availability, increased dynamic and transient grid stability and reduction of loop flows.

VII. PROPOSED METHODOLOGY

A STATCOM (Static Synchronous Compensator) is a power electronics-based device used in power systems to regulate voltage, improve stability, and provide reactive power compensation. It is a key component in Flexible AC Transmission Systems (FACTS). Here’s an overview of how a STATCOM works:

Principle of Operation:

A STATCOM is based on a Voltage Source Converter (VSC) that converts a DC voltage into a three-phase AC output. It can either absorb or inject reactive power into the grid by adjusting the magnitude and phase of its output voltage relative to the system voltage.

Components of STATCOM:

Voltage Source Converter (VSC): Converts DC voltage into a controllable AC voltage.

DC Energy Storage (Capacitor): Provides the DC voltage input to the VSC.

Coupling Transformer: Connects the STATCOM to the AC network.

Control System: Manages the operation of the STATCOM, including the modulation of the VSC to achieve the desired output.

Working Mechanism:

Voltage Control:

The STATCOM generates an AC voltage that is either in phase or out of phase with the grid voltage.

By varying the magnitude of its output voltage, the STATCOM can either absorb or inject reactive power:

If the STATCOM output voltage is higher than the grid voltage: It injects reactive power into the grid (acts as a capacitor, boosting voltage).

If the STATCOM output voltage is lower than the grid voltage: It absorbs reactive power from the grid (acts as an inductor, reducing voltage).

Reactive Power Compensation:

The reactive power (Q) injected or absorbed by the STATCOM is controlled by varying the amplitude of the output voltage relative to the grid voltage.

The VSC generates a three-phase voltage waveform with a specific amplitude and phase angle that determines whether the STATCOM acts as a source or sink of reactive power.

Control System:

The control system continuously monitors the grid voltage and adjusts the VSC to maintain the desired voltage level.

Advanced controllers, such as Proportional-Integral (PI) controllers, are used to regulate the switching of the VSC's semiconductor devices (e.g., IGBTs or GTOs).

The fast response of the control system allows the STATCOM to quickly react to changes in grid conditions, providing dynamic voltage support.

Power Quality Improvement:

STATCOMs help improve power quality by providing voltage stabilization, damping oscillations, and reducing flicker in industrial loads.

They also filter out harmonics due to the inherent capabilities of the VSC technology.

Modes of Operation:

Inductive Mode (Reactive Power Absorption):

The STATCOM acts as an inductor, absorbing reactive power from the grid.

This mode is engaged when the grid voltage is high, helping to bring it down to a stable level.

Capacitive Mode (Reactive Power Injection):

The STATCOM acts as a capacitor, injecting reactive power into the grid.

This mode is engaged when the grid voltage is low, helping to boost it.

Advantages of STATCOM:

Fast Response Time: STATCOMs can respond quickly to sudden changes in grid voltage.

Smooth Voltage Control: Provides continuous, smooth control over a wide range of operating conditions.

Compact Size: STATCOMs are more compact than traditional SVCs and require less space.

Enhanced Stability: Improves system stability and supports integration of renewable energy sources.

Applications:

Voltage regulation in transmission and distribution networks.

Support for renewable energy integration (e.g., wind and solar farms).

Mitigation of voltage sags, flickers, and other power quality issues.

Stability enhancement in weak or heavily loaded grids.

In summary, STATCOMs play a vital role in modern power systems by providing fast and reliable reactive power compensation, thereby enhancing grid stability and power quality.

VIII. RESULT AND SIMULATION

The performance of the STATCOM along with the proposed control strategy is demonstrated and discussed in this section. Moreover, the performance of the STATCOM is compared with that of the conventional SVC.

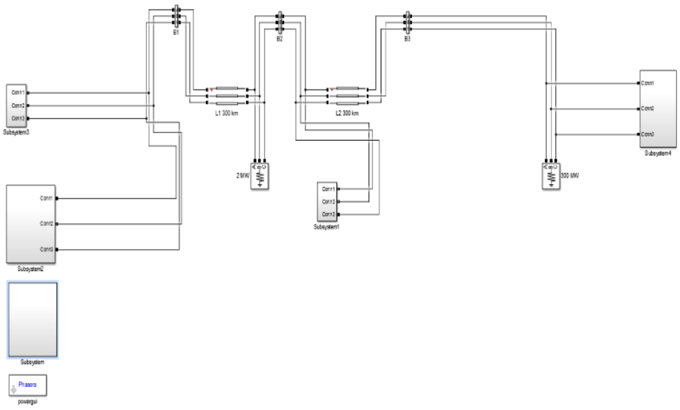

Fig.1. MATLAB 2015A STATCOM model.

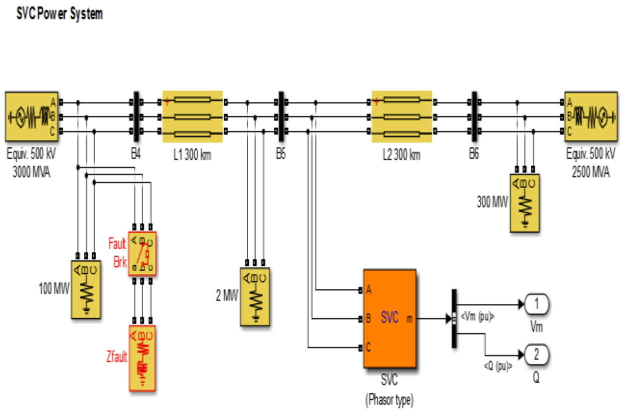

Fig.2. MATLAB 2015A SVC model.

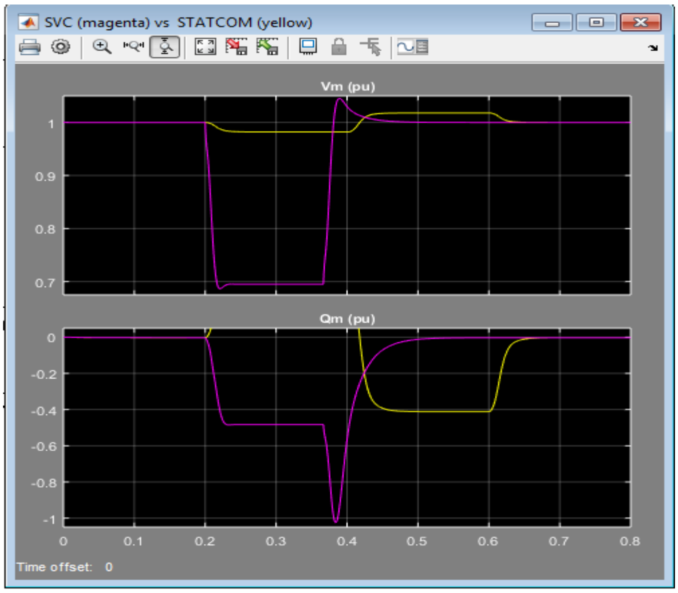

Fig.3. STATCOM model And SVC comparison.

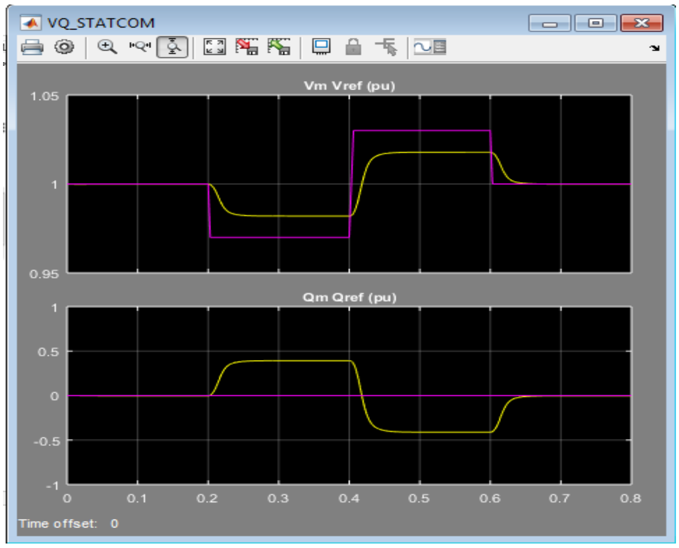

Fig.4.Refrence Power of SVC and STATCOM.

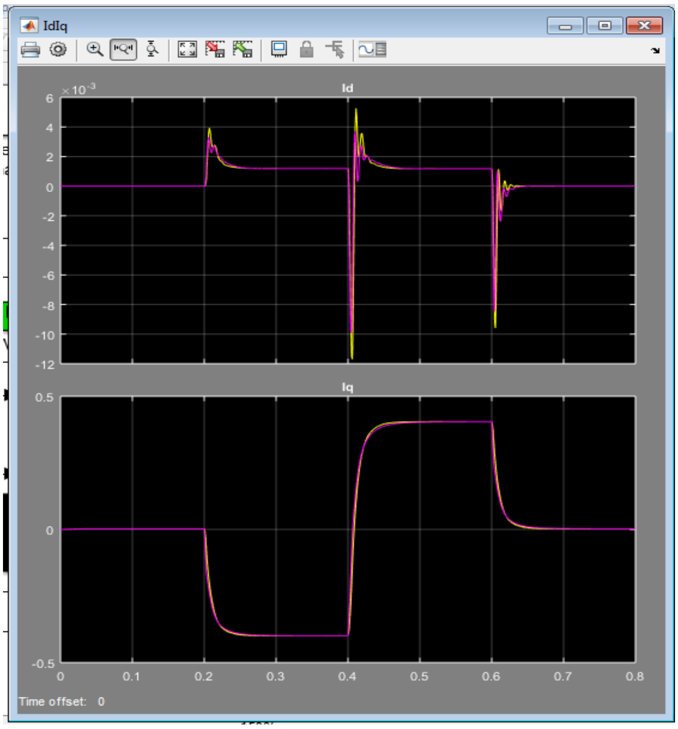

Fig.5. Per Unit Stability Index.

Comparison between SVC and STATCOM at higher fluctuation condition (0.2s-0.4s)

S.n.	STATCOM	SVC
1	0.97	0.7

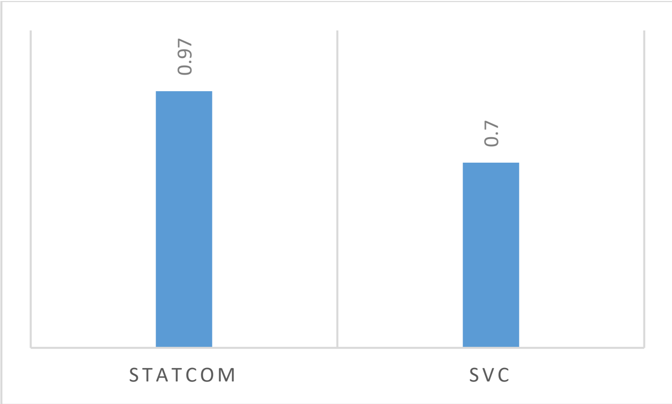

Fig.6. Comparison between SVC and STATCOM at higher fluctuation condition (0.2s-0.4s)

IX. CONCLUSION

In this paper a comparative study of SVC and STATCOM for Power system stability enhancement in different features is discussed. The different operating condition of SVC and STATCOM under various load conditions and conditions are also discussed. At the end it is proved that STATCOM gives better voltage stability compared to that of SVC with consideration of voltage stability and speed of response and it is observed that both SVC and STATCOM are able to improve voltage stability as well as power system stability. It is found also that the STATCOM is more expensive than the SVC but the physical size of STATCOM of same rating with SVC is less but at present, the cost of the STATCOM seems to be competitive with the SVC.

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