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302. Voltage Stability Improvement by Using FACTS Device Static VAR Compensator (SVC)

Bilawal Abro*, Parkash Gujar, Muharram Ali

Mehran University of Engineering and Technology Shaheed ZA Bhutto Campus KhairpurMir's Sindh Pakistan
Email Address: bilawal-abro@muetkhp.edu.pk

Abstract

"Power system engineering forms an immense and foremost part of electrical engineering studies. It is mainly concerned with generation of electrical power and its transference from Launching end to acceptance end as per client need, meet with least quantity of losses. The power at acceptance end is regularly subjected to changes because of burden distinction and due to turbulences tempted inside length of transmission line. Therefore the expression "Power System Stability" is of most extreme significance in this field, and used to characterize the inclination of framework to convey back its operation to relentless state condition inside least likely time subsequent to having experienced some kind of transition or aggravation in the line. Power System Stability depends upon various factors one of them is "voltage stability". If we don't take measure to preserve the voltage stability in our power system, ultimately we have to face worst conditions under such circumstances that is voltage collapse & how we can mitigate it. In order to improve voltage stability and diminish the losses of power system we are using one promising FACTS device called "Static VAR Compensator". Static VAR Compensator using the modern technology of power electronic switching device in the arena of power transmission system economically enhancing the voltage regulation. The Static VAR Compensator is increasingly applied in electrical power transmission system economically to improve the post disruption retrieval voltages that can lead to system instability. We will study few models using MATLAB for scrutinizing the above defined parameters of power system. How they act and what impact of SVC on power system."

Keywords: *"FACTS (Flexible AC Transmission System); SVC (Static VAR Compensator)"*

1. Introduction

Day by Day, demand on transmission network are increasing due to escalating number of non-utility generators and utility among your contenders. The increase in demand on transmission system, the lack of long term planning and the need to provide open access to energy production firms and consumers; all together they have created trend toward a reduction in safety and reduction in quality of supply. The alternating current transmission system has several limitations, classified as static and dynamic limits [1-3]. These inherent limitations restrict the feeding operation, which lead to under-utilization of existing transmission resources. Conventionally, motionless or mechanically switched capacitor series and shunt reactors and synchronous generators have been used to solve many of these problems. However, there are some constraints on the use of these conventional strategies. It was able to attain desired performance successfully. The wear of mechanical components and sluggish response were the biggest glitches. As a result, it has been necessary for alternative technology power electronic devices with fast response characteristics. The requirement has been further fueled by the restructuring of worldwide utilities, environmental regulations, and increasing efficiency and difficulty in obtaining permits and right of way for the construction of electricity transmission, materials mounting [4]. This, along with the invention of the thyristor semiconductor switch, opened the door for the development of FACTS controllers. The route drivers based historical facts to modern thyristor converters technically advanced voltage source based FACTS controllers, made possible by rapid progress in high-power semiconductor switching devices [1-3]. A compensator Static VAR (SVC) is an electrical device to provide reactive power compensation fast action in networks of high voltage transmission and can help improve the voltage profile in the transient state and, therefore, improving the performances of quality electrical services. An SVC is one of the FACTS controllers, which can control one or more variables in a power system [5]. The dynamic nature of the superior vena cava is the use of thyristor devices (e.g, GTO, IGCT) [4]. The thyristor, which is usually located inside a "house of the valve" can change the capacitors or inductors input and output circuit on a per-cycle, allowing rapid superior control system voltage.

The compensator studied in this paper consists of a fixed reactor connected in series to a thyristor-controlled (TRC) reactor, based on bi-directional valves- and a fixed capacitor bank in parallel with the combination reactor-TRC. The thyristors are activated by suitable control which regulates the magnitude of the current.

2. Static VAR Compensator

2.1 Configuration of SVC

SVC provides an outstanding source of shunt reactive compensation quickly controllable for dynamic voltage control through use of thyristors high-speed switching / controlled devices [6]. A SVC is generally composed of coupling transformer, thyristor regulators, reactors, capacitance (often tuned for harmonic filtering).

2.2 Advantages of SVC

The main advantage of SVC on simple, mechanically switched compensation schemes is their almost instantaneous response to variant the system voltage. For this cause, they are often used close to their zero point, to maximize the correction of reactive power [7] - [10]. They are larger overall capacity cheaper, faster and more reliable than dynamic compensation systems as synchronous compensators (condensers). In a word:

1) Improved system stability at steady state.
2) Improved stability in the transitional system.
3) Better division burden on parallel circuits.
4) Reduced voltage drops in load areas for serious disorders.
5) Reduction of transmission losses.
6) Better adaptation expense line.

2.3 Control Concept of SVC

SVC is a controlled shunt susceptance (B), as defined by the control settings injecting reactive power (Q) for the system based on a square of the terminal voltage. Fig. 1 illustrates an SVC TCR, containing the operational concept. The control objective is SVC to maintain a desired voltage on the high voltage bus. At steady state, the SVC will provide a steady state control voltage to keep the high voltage bus to a predefined level.

If the high voltage bus begins to fall lower than its range of set point, the SVC will inject reactive power (Qnet). In increasing the voltage of the bus back to your network desired level of tension. If the bus voltage increases, the SVC will inject less (or TCR will absorb more) phantom power, and the result will achieve the desired bus voltage. From Fig. 1, + QCAP is a fixed capacitance value, so the magnitude of the reactive power injected into the system Qnet is controlled by the magnitude of reactive power absorbed by the TCR-Qind. The foundation operation of the valve which controls the thyristor TCR is described here. The thyristor switch is self each zero current, therefore the current through the reactor is obtained by gating or triggering the thyristor into a conducting or desired firing angle in relation to the voltage waveform [11].

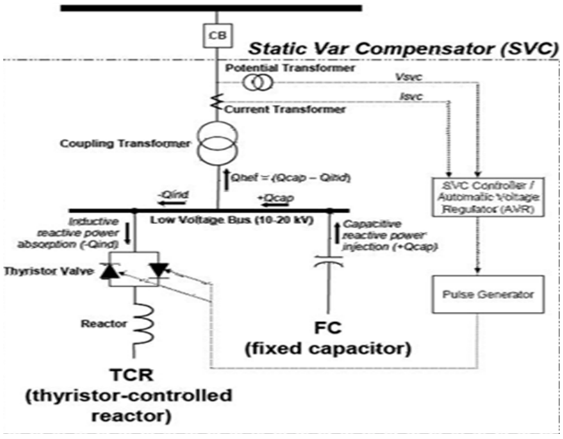


Fig. 1 SVC TCR

3. Static VAR Compensator

The base of the thyristor-controlled reactor (TCR) shown in Fig. 2. The control element is the thyristor controller, shown here as two oppositely propelled thyristors conducting alternate half cycles in the power frequency. If the thyristors are closed in driving precisely the peaks of the supply voltage, the results of driving full in the reactor, and the current is the same as if the driver were shorted thyristors.

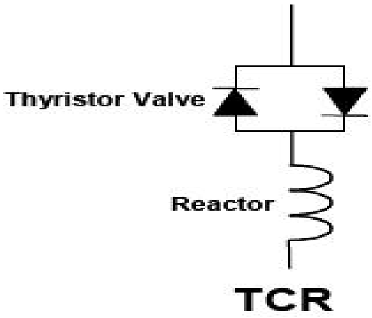


Fig. 2 TCR

3.1 Principle of Operation

The reactive current is primarily going voltage at about 90^0. It has a small in-phase components due to power losses in the reactor, which can be of the order of 0.5-2% reactive power. Total drive current shown by the waveform in Fig. 3 (a). If the gating is stuck by equal amounts on both thyristors, a series of current waveform is obtained, such as in Fig. 3 (a) to 3 (d). Each of these corresponds to a particular value of α propagation angle which is measured from a zero crossing of the voltage. Total drive is attained with an angle part 90^o. Drive selection is obtained from propagation angles between 90^0 and 180^0. The effect of increasing the propagation angle is to reduce the fundamental harmonic component of the current. This is equivalent to an increase in the inductance of the reactor, reducing its reactive power, as well as its current. So far as the major component of current is concerned, the reactor is controlled by a controllable thyristor susceptance, and can therefore be applied as a static compensator.

4. Performance Analysis of SVC Controller

4.1 Modeling for Dynamic Performance Analysis with SVC Applications

By studying the performance of the system and dynamic voltage control, system modeling is an important aspect, especially in and around the specific area of study. It is typical of many power companies to share large system models consisting of thousands of buses representing the interconnected system. The details of the modeling are discussed elements "system" such as transformers, generators, transmission lines and shunt reactive devices (ie, capacitors, reactors), etc., for short term stability analysis. A significant aspect and continually debated modeling is the model "load". For the short-term stability analysis, the loads are modeled with both (eg real power, reactive power) static and dynamic characteristics [12]. The block control voltage automatic regulator (AVR) is an important part of SVC models that operate in a voltage error signal. The AVR basic control block is defined by the transfer function as shown in Fig. 3.

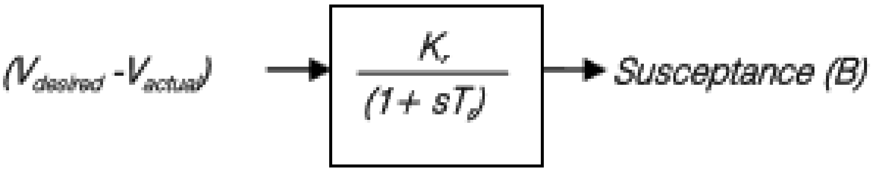


Fig. 3. Transfer Function of AVR Control Block

Where Kr and T_r indicates the gain and time constant, respectively. The tilt adjustment, maximum and minimum Susceptance, thyristor firing lag transport, lag measuring voltage, etc. are the functions of the additional control block commonly used dynamic models SVC.

4.2 Controller Design Analysis

SVC is operated as a bypass device for supplying power to support voltage or inductance to reduce the bus voltage. The fixed capacitors are tuned to absorb the harmonics generated by the TCR operation. Although the SVC is able to provide support for the short-term stability and power oscillation damping, its main function is to support dynamic voltage and reactive power. The SVC in principle is a controlled shunt susceptance (+/- B) as defined by the SVC control settings injecting reactive power (+ Q) or remove reactive power (Q) based on the square of its terminal voltage. The block diagram shown in Fig. 4.

In this application, Q = V2 × B, and L and C are the components that are dimensioned such that Q≥ 0 is the single margin of operation. The AVR in the form of proportional and integral control, operates in a voltage error signal there are also measuring delay (DT) and thyristor transport lag burning (T1). The B output of this control block diagram of the pulse generator feeding controller that generates the thyristor trigger signal required for the light triggered TCR.

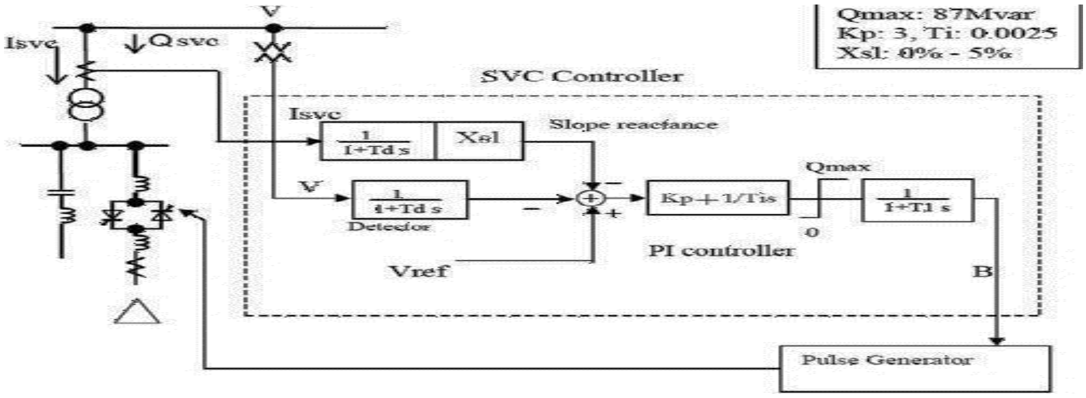


Fig. 4: Detailed SVC Block Diagram

4.3 Performance Criteria of SVC Operation

The control objective is to uphold the system voltage in 275 kV bus at 0.038+j0.32 p.u. Voltage. If the bus starts to drop below 0.038+j0.32 p.u., SVC will inject reactive power (Q) in the system (controlled within their limits), thereby growing the bus voltage back to its desired 0.038+j0.32 p.u. voltage according to its tilt configuration, XSL. On the contrary, if the bus voltage increases, the SVC will inoculate less (or TCR will absorb more) reactive power (within their controlled limits), and the result will be the voltage required bus in [9]-[10]. Simulink block diagram of SVC controller is given in Fig. 5.

The steady state response in SVC will follow the current-voltage (IV) characteristic curve shown in Fig. 6. The feature VI is used to illustrate the VCS classification and steady state performance in the typical region of operation steady state is mainly based setting Vref in, XSL, and system impedance.

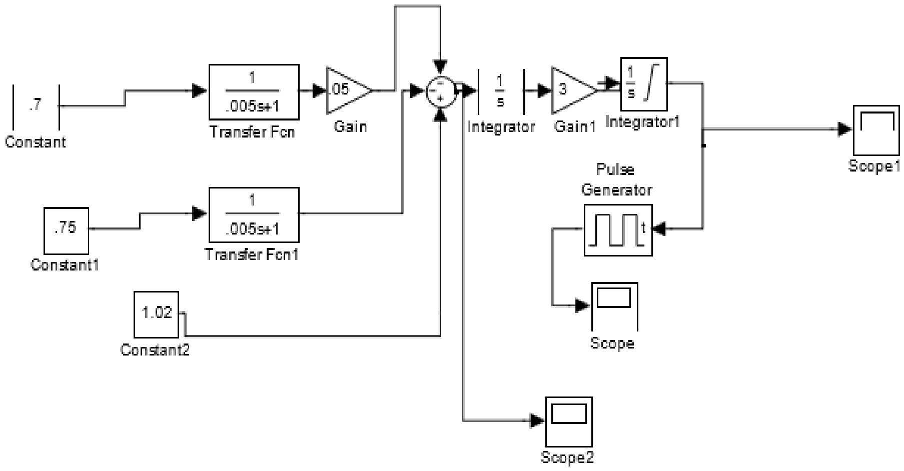


Fig. 5. Simulink Block Diagram of SVC Controller

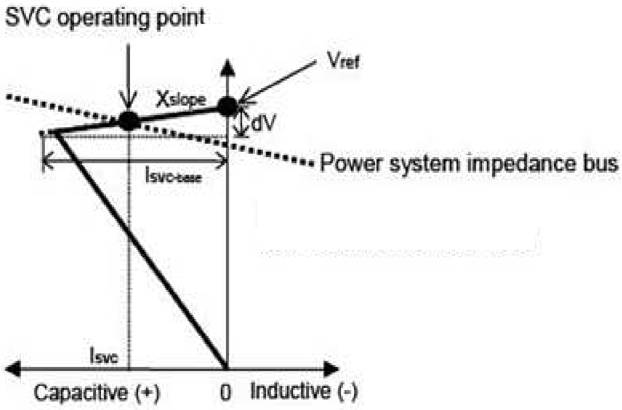
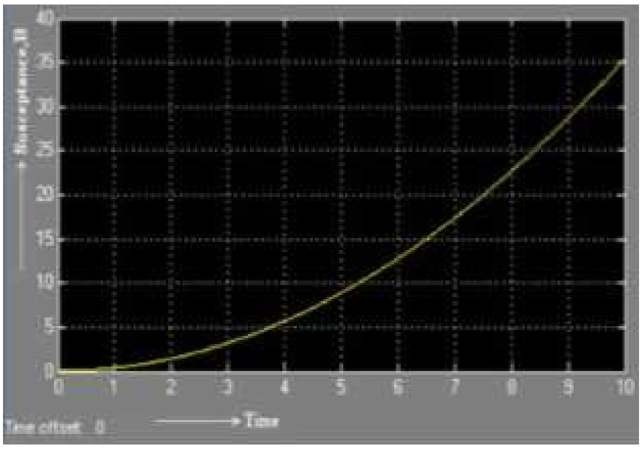


Fig. 6. Steady State V-I Characteristics of SVC

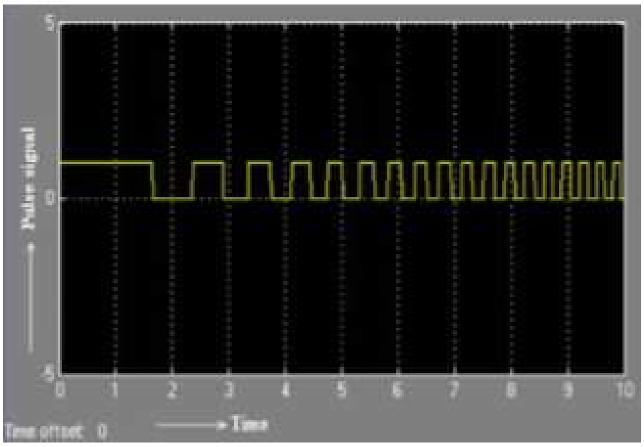
4.4 Typical Parameter of SVC

Table 1. Typical parameters for SVC model

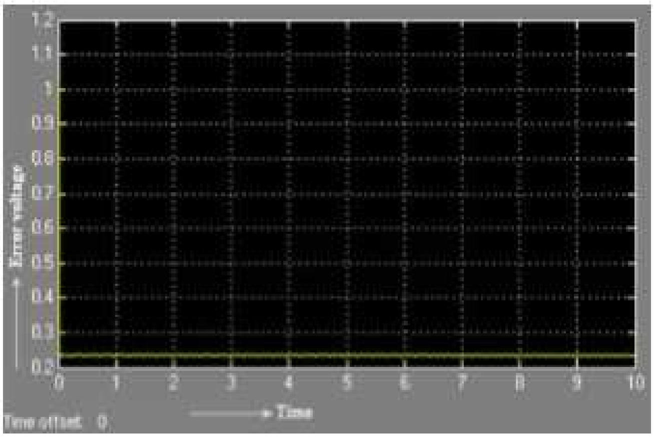
Parameter	Definition	Typical Value
T_d	Time Constant	0.001-0.005
T_1	Time Delay	0.003-0.006
X_{sl}	Slope Reactance	0.01-0.05 pu



Scope 1: The Required Pulse



Scope 2: The Susceptance which is increased due to drop of the Bus Voltage

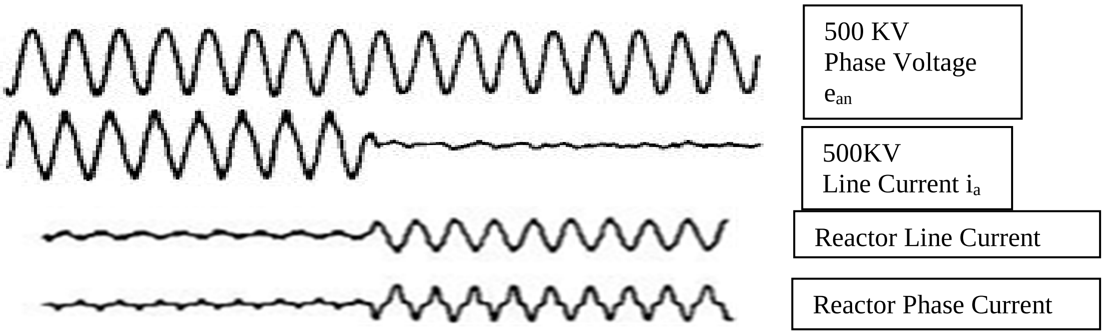


Scope 3: The Voltage Error Signal

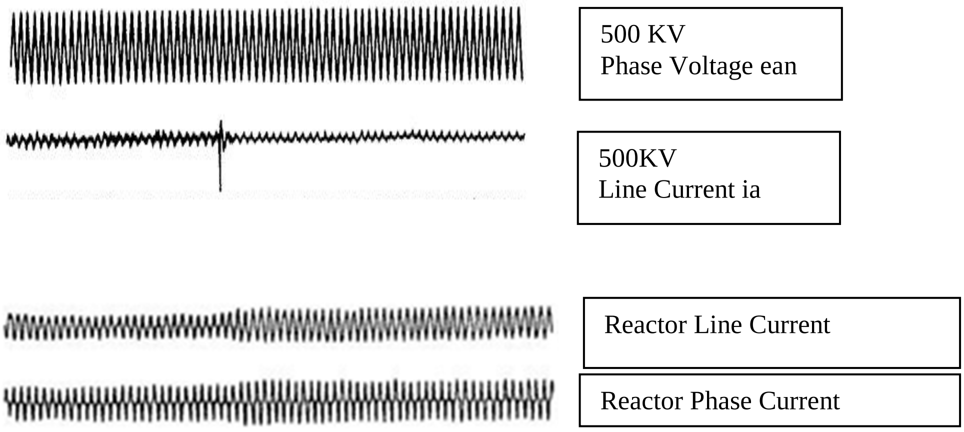
5. Performance Testing

HUB – JSO is a 500kV single circuit line of 181 kM. This line consists of 4 wire bundle conductor arrangement. The conductor used in this circuit is code named GREELEY. Greeley is an AASC (Aluminum Alloy Stranded conductor) type conductor. When wind velocity is zero m/s, a current fellow of 566 A will rise the conductor temperature to 40 degree Celsius, and current fellow of 681A will rise conductor temperature to 50 degrees Celsius. When wind velocity is 0.61m/s (2.2km/h), a current fellow of 791 A will rise the conductor temperature to 40 degree Celsius, a current fellow of 901A will rise conductor temperature to 50 degrees Celsius. An extensive series of tests was made during and after commissioning to check the performance of the compensator. These tests included measurements of regular transfer function.

Case-1: Voltage and current waveforms as shown in Fig. 7(a).



Case-2: Energizing the capacitor bank producing a sudden change of MVAR as shown in Fig. 7(b).



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