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# A Review Article Of High Voltage Power Distribution & Power Stability Enhancement Using Svc Controller

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**Abstract-Since the beginning of the last century, power system stability has been recognized as a vital problem in securing system operation. Power system instability has caused many major blackouts. This paper reviewed the previous technical works consisting of various methods of optimization in controlling power system stability. The techniques presented were compared to optimize the control variables for optimization of power system stability. Power system stability enhancement has been investigated widely in literature using different ways. This paper is focusing on SVC performance for enhancing power system stability either through SVC controlled itself or SVC controlled externally by other controllers. Static VAR compensators (SVCs) are used primarily in power system for voltage control as either an end in itself or a means of achieving other objectives, such as system stabilization.The analysis on performance of the previous work such as advantages and findings of a robust method approach in each technique was included in this paper.**

**Keywords - MATLAB Software Toolbox, Newton-Raphson method, Power flow, Power flow with SVC FACTS Controller Algorithm, Reactive Power Compensation.**

## I. INTRODUCTION

Power systems at a glance The major challenge faced by power system today is its stability in existing transmission and distribution facilities Power system should retain its synchronism during and after all these kind of perturbations. Therefore the transient stability is an important security in power system design. So FACTS devices are introduced to improve the power system stability. For many reasons desired performance was being unable to achieve as required. A static VAR compensator (SVC) is an electrical device for providing fast acting reactive power compensation on high voltage transmission.

In addition to this, it also enhances the power system stability in the network. [1] Networks and it can contribute to improve the voltage profiles in the transient state and therefore, it can improve the qualities and performances of the electric utilities. An SVC can be controlled externally by using properly designed different types of controllers which can improve voltage stability of a large-scale power system network. However, in this study, with a view to get better performance,

A new PI, Fuzzy logic and Hybrid PI-fuzzy logic controller have been designed & proposed and used along with SVC for improvement of power system stability. The dynamic nature of the SVC lies in the use of thyristor (semi-conductor) devices. Therefore, thyristor-based SVC with controllers have been used to improve the performance of power system. FACTS devices defined according to IEEE standard are "A power electronics/semiconductor devices supported system and other additional device that facilitates control of various AC power system factors to improve control ability and capability of power transfer". [2]

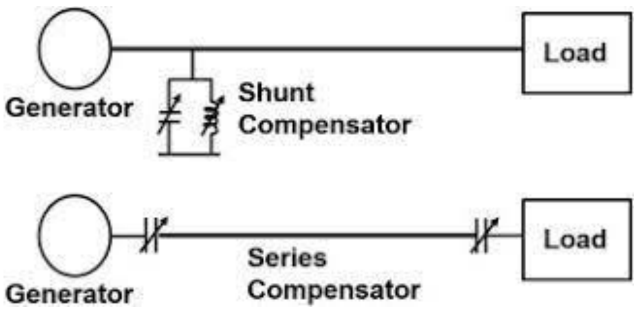


Fig.1.1 FACTs Compensator.

## II. RESEARCH MOTIVATION

As the power systems are becoming more complex it requires careful design of the new devices for the operation of controlling the power flow in transmission system, which should be flexible enough to adapt to any momentary system conditions. The operation of an ac power transmission line is generally constrained by limitations of one or more network parameters and operating variables by using FACTS[3] technology such as SVC (Static Var Compensator), the bus voltages, line impedances, and phase angles in the power system can be regulated rapidly and flexibly. N-R power flow is very important tool for the analysis power systems and it is used in operational and planning. The main objective of power flow is calculating unspecified bus voltage angles and magnitudes. The FACTS controllers offer a great opportunity to regulate the transmission of alternating current (AC), increasing or diminishing the power flow in specific lines and responding almost instantaneously to the stability problems. The potential of this technology is based on the possibility of controlling the route of the power flow and the ability of connecting networks that are not adequately interconnected, giving the possibility of trading energy between distant agents. Flexible Alternating Current Transmission System (FACTS) is static equipment used for the AC transmission of electrical energy. It is meant to enhance controllability and increase power transfer capability. It is generally power electronics based device.

The FACTS devices can be divided in three groups, dependent on their switching technology: mechanically switched (such as phase shifting transformers), thyristor switched or fast switched, using IGBTs. While some types of FACTS, such as the phase shifting transformer (PST) and the static VAR compensator (SVC)[4] are already well known and used in power systems, new developments in power electronics and control have extended the application range of FACTS[6].

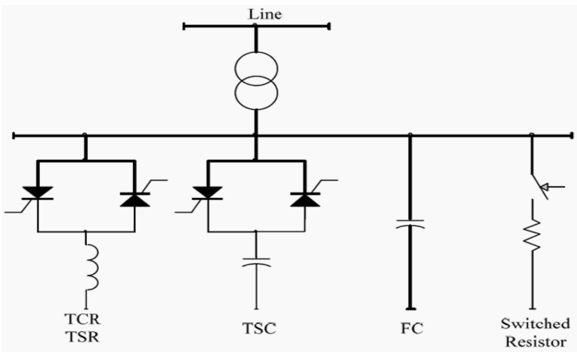


Fig.2. SVC device.

Now total Fourier series harmonics SVC current are-

$$I_1(\alpha)= a_1 coswt+b_1 sinwt$$

Where $b_1 = 0$ because of the odd-wave symmetry, that is, $f(t) = f(-t)$. Also, no even harmonics are generated because of the half-wave symmetry, i.e., $f(t + T/2) = -f(t)$. The total effective reactance of the SVC

$$X_{SVC}=\frac{XC*XTCR}{XC+XTCR}$$

Wherecapacitive reactance of $X_C$ = 1.1708 pu and $XTCR$TCR equivalent reactance.

## III. LITERATURE REVIEW

S.M.Abd-Elazim, Bacteria Foraging Optimization Algorithm based SVC damping controller design for power system stability enhancement: This paper proposes Bacteria Foraging Optimization Algorithm (BFOA) based Static Var Compensator (SVC) for the suppression of oscillations in a multimachine power system. The proposed design problem of SVC over a wide range of loading conditions is formulated as an optimization problem. BFOA is employed to search for optimal controller parameters by minimizing the time domain objective function. [1].

M.A.Abido, Coordinated design of a PSS and an SVC-based controller to enhance power system stability: Power system stability enhancement via robust coordinated design of a power system stabilizer and a static VAR compensator-based stabilizer is thoroughly investigated in this paper. The coordinated design problem of robust excitation and SVC-based controllers over a wide range of loading conditions and system configurations are formulated as an optimization problem with an eigenvalue-based objective function. The real-coded genetic algorithm is employed to search for optimal controller parameters[2].

Swapnil D.Patil, Performance enhancement of modified SVC as a thyristor binary switched capacitor and reactor banks by using different adaptive controllers: In this paper, a new topology with two shunts flexible AC transmission system (FACTs) devices, thyristor binary switched capacitors (TBSC), and thyristor binary switched reactors (TBSR) based SVC have been developed, which are working in parallel. Both TBSC and TBSR are designed, and simulation results are obtained for the dynamic loading condition. Switching of capacitor and reactor banks with thyristor as a switch is obtained at transient free conditions so that the significant problem of switching harmonics is eliminated.It has near to zero switchings and zero steady-state harmonics. The mathematical model of TBSC + TBSR has been identified with the system identification toolbox. Different control strategies are implemented as PID controller, Model predictive control, and Model reference adaptive control. The proposed SVC topology performance is discussed based on the performance parameters such as rise time, settling time, and peak overshoot using adaptive controllers [3].

ShibaR.Paital, Stability improvement in solar PV integrated power system using quasi-differential search optimized SVC controller: In this paper, the simulation results of static var compensator (SVC) for improvement of transient stability in a photo voltaic (PV) system integrated power system are presented. A Proportional Integral Derivative (PID) controller was also incorporated with SVC for contributing necessary damping in case of various disturbance conditions. Here, the dynamic stability of the PV based power system was studied in single machine infinite bus (SMIB) and power system. SVC is integrated with the above PV based power system for damping low frequency oscillations produced due to disturbances in the power system. Further a novel soft

computing based approach called quasi-oppositional differential search algorithm (QODSA) was for designing an optimal SVC-PID based damping controller. Initially DSA was applied for optimizing the gains of the controller and finally quasi oppositional learning was incorporated to DSA for obtaining the optimal parameters of SVC-PID controller and also for enhancing the convergence speed[4].
HamidRezaie, Enhancing voltage stability and LVRT capability of a wind-integrated power system using a fuzzy-based SVC: The static var compensator (SVC) has widespread applications in voltage regulation and stability improvement of power systems. This paper studies the SVC performance in a single machine (doubly-fed induction generator (DFIG) employed in a wind farm) infinite bus (SMIB) system. The SVC is employed to improve the voltage stability of the system and the low voltage ride-through (LVRT) capability of the wind farm. To enhance the effectiveness of the SVC, a supplementary fuzzy-based controller (FC) is proposed and is integrated into the SVC controller. The use of the proposed FC leads to the increasing the accuracy of the SVC controller that results in improving its performance in both transient and steady state. By using the proposed controller, the steady state voltage is enhanced and the maximum voltage drop under fault situations is decreased. Less voltage drop after the fault occurrence using the proposed FC results in improving the LVRT capability and makes the wind farm able to meet the grid code requirements in a larger range of load variations in the system[5].

RamakantaJena, Power flow simulation & voltage control in a SPV IEEE-5 bus system based on SVC: Static var Compensator (SVC) can be controlled in a coordinated manner for achieving the voltage regulation and transient stability for increasing the performance of power system. In this paper some linearization techniques like parameter uncertainties are considered for increasing the performance of the system. SVC can enhance the plant parameters for improved power flow, voltage stability and transient stability. In this paper a simulink model has been presented in MATLAB where main focus is to integrate the SVC controller with Solar photovoltaic (SPV) as Generator bus, so that voltage regulation, loss minimization & nodal voltage magnitude improvement can be done properly[6].

Prakash K.Ray, Improvement of Stability in Solar Energy Based Power System Using Hybrid PSO-GS Based Optimal SVC Damping Controller: This paper presents a dynamic stability study in a solar energy based power system connected to infinite bus based on optimal design of a Static Var Compensator (SVC). In the proposed study, SVC is incorporated in order to improve the rotor angle and voltage oscillations because of different disturbances created in the power system. A new computational hybrid optimization approach using Particle Swarm Optimization (PSO) and Gravitational Search (GS) technique is considered for designing an optimal SVC damping controller for an improved dynamic performance. The optimization technique is used for tuning the gains of proportional integral derivative (PID) controller. Transient oscillation results for conventional PID, PSO optimized PID and PSO-GS based PID are compared analytically as well as quantitatively. It is observed that the proposed PSO-GS based PID controller is robust and effective in minimizing the oscillations in the system as compared to the other two and thus improves the stability [7].

Asit Mohanty, Intelligent Controller based SVC for Voltage Stability Improvement in a Stand-alone Wind-Diesel-micro Hydro Hybrid System: This paper gives a novel idea of application of ANN based SVC controller for voltage stability improvement in an isolated wind-diesel-micro hydro hybrid system. For detailed analysis a small signal linear model of the hybrid wind- Diesel-micro hydro model is considered with different loading conditions. The voltage stability analysis has been thoroughly analysed by a SVC Controller and is further improved by a feed forward neural network with back propagation technique which is designed to tune the parameters of SVC controller[8].

JawaharlalBhukya, Optimization of controllers parameters for damping local area oscillation to enhance the stability of an interconnected system with wind farm: In a power system with renewable energy sources, the Low-Frequency Oscillatory (LFO) modes arise due to the intermittent nature of wind power, loading and generating conditions. This is undesirable and results in system instability. If these LFO modes are not controlled, it may lead to a power interruption and results in unstable. The LFO modes are damped by Power System Stabilizers (PSS). However, it causes variation in voltage profile resulting in reduction instability of the system during large disturbances. In such cases, the flexible ac transmission system controllers are required.

This paper presents and compares the PSS, Static synchronous Compensator (STATCOM) and Static Var Compensator (SVC) controller by replacing Synchronous Generator (SG) with same rated wind farm and various wind power penetration levels by considering system uncertainties such as wind speed. In this paper, a robust coordinated method is proposed using Particle Swarm Optimization (PSO) for optimizing parameters of controllers of PSS, SVC, and STATCOM. The real part and damping ratio of eigenvalues is the objective function for PSO and is formulated based on the small-signal and transient analysis. Controller locations are determined by the deterministic method, probabilistic method and power flow sensitivity analysis. An eigenvalue analysis approach based on the linearization of a nonlinear system using a state-space model is conducted to analyse the Small Signal Stability performance[9].

Y.Wang, A nonlinear controller design for SVC to improve power system voltage stability: This paper discusses a nonlinear controller design for Static Var Compensator (SVC) to improve power system voltage stability. A third-order nonlinear dynamical description for the SVC system is developed. Direct feedback linearization (DFL) technique is employed to design a nonlinear controller. The effectiveness of the controller on voltage stability enhancement is studied on a three-bus power system through time simulation and bifurcation analysis. The results show that the collapse time is put off and the subcritical Hopf bifurcation is greatly affected by the controller[10].

MohsenFarahani, Intelligent control of SVC using wavelet neural network to enhance transient stability: In order to enhance transient stability in a power system, a new intelligent controller is proposed to control a Static VAR compensator (SVC) located at center of the transmission line. This controller is an online trained wavelet neural network controller (OTWNNC) with adaptive learning rates derived by the Lyapunov stability. During the online control process, the identification of system is not necessary, because of learning ability of the proposed controller. One of the proposed controller features is robustness to different operating conditions and disturbances. The test power system is a two-area two-machine system power. The simulation results show that the oscillations are satisfactorily damped out by the OTWNNC [11].

BindeshwarSingh, Enhancement of voltage profile by incorporation of SVC in power system networks by using optimal load flow method in MATLAB/Simulink environments: Flexible AC Transmission Systems (FACTS) controllers could be a suitable alternative to provide reactive power support at the load centers locally and hence keep the voltages within their safe operating limits. Due to high costs of FACTS devices, their proper location in the system must be ascertained. The fundamental object of this thesis work is to improve the voltage profile by reducing the real and reactive power loss in the system. The voltage profile in the system is being improved by using the FACTS device Static VAR Compensator (SVC). In this paper, studies and analyzes SVC technology for voltage enhancement, reducing system losses, suppression of fluctuations.

The effectiveness of the proposed method has been tested on IEEE-9 and IEEE-30 bus systems. Optimal placement has been obtained for the base case loading and to verify its locations. To achieves the optimization of the location and the size of the power system to optimize the system performance. A Newton–Raphson Load Flow problem has been formulated with an objective to improve the voltage profile with minimization of the losses. Moreover, the effects of SVC on economic condition have also been investigated. The results obtaining is in the form of the plot and compared with the plots without SVC. This work also helpful for whose persons are working in the field of FACTS controllers planning [12].

X.Y.Bian, Coordinated design of probabilistic PSS and SVC damping controllers: This paper presents an application of probabilistic theory to the coordinated design of power system stabilizers (PSSs) and FACTS controllers, taking static VAr system (SVC) as an example. The aim is to enhance the damping of multi electro-mechanical modes in a multimachine system over a large and pre-specified set of operating conditions. In this work, conventional eigenvalue analysis is extended to the probabilistic environment in which the statistical nature of eigenvalues corresponding to different operating conditions is described by their expectations and variances. Probabilistic sensitivity indices (PSIs) are used for robust damping controller site selection and for optimization objective functions. A probabilistic eigenvalue-based objective function is employed for coordinated design of PSS and SVC controller parameters. The effectiveness of the proposed controllers is demonstrated on an 8-machine system [13].

SylwesterRobak, Robust SVC controller design and analysis for uncertain power systems: A Static Var Compensator (SVC) installed in a power transmission network can be effectively used to enhance the damping of electromechanical oscillations [Schweickardt, H. E., Romegialli, G., & Reichert, K. (1978). Closed loop control of static VAR sources (SVS) on EHV transmission lines. IEEE Pes winter power meeting, (paper no A78, pp. 135–136), New York, Jan. 29–Feb. 3]. An adequately designed robust controller, which takes into account variations in the operating conditions, can help to achieve the desired damping control. The proposed approach described in this paper is aimed to achieve damping of electromechanical oscillations by considering a systematic approach, based on interval systems theory and Kharitonov's Theorem. The method presented allows for the design of a fixed-parameter, low-order controller, given a supposed stability degree of the system. The synthesis of a robust SVC controller is divided into two tasks. The first is the determination of the region of stability in the controller parameter plane by plotting the stability boundary locus. The second task is the optimization of the selected controller parameters from the obtained solutions to the first task. Examples of eigenvalue analysis and time simulation demonstrate the effectiveness and robustness of the designed controller [14].

A.H.M.A.Rahim, Enhancement of power system dynamic performance through an on-line self-tuning adaptive SVC controller: Static VAr compensators (SVC) are used for voltage control of long distance bulk power transmission lines. By using a supplemental control loop an SVC can also be used to improve the dynamic and transient stability of a power system. Use of a self-tuning adaptive control algorithm as a supplementary controller for the SVC is presented in this article. The control derived is based on a pole-shifting technique employing a predicted plant model. Simulation studies on a simple power system model showed rapid convergence of the estimated plant parameters with an extremely good damping profile. The controller has been tested for ranges of operating conditions and for various disturbances. The effectiveness of the adaptive damping controller was also evaluated through an ‘optimized’ PI controller [15].

## IV. CONCLUSION

The Flexible AC Transmission System (FACTS) technology is a promising technology to achieve complete deregulation of power system based on power electronic devices, used to enhance the existing transmission capabilities in order to make the system flexible and independent in operation then the system will be kept within limits without affecting the stability. Complete closed-loop smooth control of voltage can be achieved using shunt connected FACTS devices. Static VAR Compensator (SVC) is one of the shunt connected devices, which can be utilized for the purpose of voltage and reactive power control in power systems. In this paper the considered structure of SVC consists of (TCR-FC) which is applied at SMIB system model, the dynamic equations for the (SMIB-SVC) model will be presented, the system equations expressed in terms of state space equations then by using MATLAB the plant of the system model will be presented under various loading conditions.

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