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# **Analysis of Artificial Neural Networks based Power System Stabilizer Design for Reactive Power Regulation in Power System**

**Leena Chaukiker<sup>1</sup>, Shiv Kumar Tripathi<sup>2</sup>**

PG Student, Department of Electrical and Electronics Engineering, Corporate Institute of Science & Technology,  
Bhopal, MP, India

Assistant Professor, Department of Electrical and Electronics Engineering, Corporate Institute of Science &  
Technology, Bhopal, MP, India

**ABSTRACT:** The Use Of flexible ac transmission system (FACTS) controllers in power system transmission has been of worldwide interest in recent years for increasing the power transfer capability and enhancing power system controllability and stability. This paper gives a novel idea of application of ANN based SVC controller for voltage stability improvement in Power system. Voltage level of the system changes at the time of fault and the drop in the load voltage leads to an increased demand for the reactive power that, if not met by the power system leads to a further decline in the bus voltage. This decline eventually leads to a progressive rapid decline of voltage at that location, which may have a cascading effect on neighboring regions that causes voltage collapse. In this paper, In order to maintain system stability after faults, the transmission line is shunt compensated at its center by Static Var Compensator (SVC) in MATLAB / SIMULINK. SVC was used to maintain the voltage within the limits. SVC will either supply the reactive power or extract the reactive power. An Artificial Neural Network (ANN) is also developed with a systematic step-by-step procedure which optimizes a criterion commonly known as the learning rule. The input/output training data is fundamental for these networks as it conveys the information which is necessary to discover the optimal operating point. It is shown that trained Neural Network developed has excellent capabilities of forecasting which can be very useful in research.

**KEY WORDS:** Static Var compensator (SVC), shunt compensation, Artificial Neural Network (ANN) , Transmission line, Reactive Power

## **IINTRODUCTION**

The technology such as flexible AC transmission system (FACTS), can help to find the solution. Facts devices provide voltage support at critical buses in the system (shunt connected controllers) and regulate power flow in critical lines (with series connected controllers) [1]. The need for these power flow controllers capable of increasing transmission capability and controlling power flows is increasing. Power transfer, in most integrated transmission systems, is forced by transient stability, voltage stability, and power stability. FACTS technology is predicated on the utilization of reliable high-speed power physics, advanced control technology, high-octane microcomputers and powerful analytical tools. The key feature is that the accessibility of power electronic shift devices that may switch electricity at power unit levels (kV levels). Owing to the environmental and economic pressures, electric power system becomes more heavily loaded and system oscillations are increased. Inadequate damping of these oscillations will restrict the power transfer capability. The conventional PSS (CPSS) is widely utilized to enhance the system damping. In some cases, if the utilization of PSS cannot provide sufficient damping for inter-area power swing, Flexible AC transmission systems (FACTS) devices are substitute effectual solutions. The principle of these FACTS devices is to regulate the reactance and voltage. SVC is the most popular FACTs device utilized to improve the reliability of power systems [2]. It has different capability to improve the operation of power systems by mitigating network loss, providing voltage regulation, compensating active power, improving transient stability, limiting short circuit currents and damping the power system oscillation. Static Var Compensator (SVC) is one of the earliest Flexible AC Transmission System (FACTS) devices. It generates or absorbs reactive power at its point of connection, usually in the middle of a high voltage transmission line. Before the evolution of SVC in the 1960s, synchronous compensators performed such

compensation. Generally, SVC is used to maintain the voltage magnitude at the middle of a long transmission line, thereby to increase the power transfer capability in a given transmission line. Since SVC cannot generate or absorb real power (neglecting its relatively low internal losses), the power transmission of the system is affected indirectly by the voltage control. SVC regulates the voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system. When the system voltage is low, SVC generates reactive power (capacitive mode) and when the voltage is high, it absorbs reactive power (inductive mode) [3]. However, the employment of a SVC in a transmission line creates certain problems for the protective relays and fault locators using conventional techniques because of the rapid changes introduced by the associated control actions. The methodology of Artificial Intelligence (AI) has successfully contributed to the design of adaptive control systems for various types of applications. The merits of high speed, robustness and generalization ability are of considerable advantage in power system applications. ANNs based PSSs have been widely investigated and shown to provide good performance in terms of system identification and designing a control system. Various kinds of network topologies have been developed to construct different types of ANNs. One of the most well-known network topologies is the use of an indirect adaptive control scheme where two networks are employed, one as a neuro-identifier and the other as a neuro controller. The neuro-identifier is used to estimate the dynamic model of the plant and provide an update to the neuro-controller. The neuro-controller is used to produce a supplementary control signal. The neuro-identifier and neuro-controller parameters are updated on-line using a back-propagation algorithm. In this manner, the controller can adapt to the changes in the system configuration and operating conditions. The proposed control scheme includes many feedback loops that are arranged for such a manner and increase the certainty of the response. Items tested opens a transmission line in two circuit transmission line that cause sudden changes in load demand and three-phase short-circuit fault.

## II.SVC BASED-POWER SYSTEM STABILIZER

Flexible AC Transmission System (FACTS) controllers modify the series and parallel impedances of transmission lines. The way a FACTS controller is connected to the ac power system has a direct effect on the transfer of active and reactive power within the system. Series connected controllers are usually employed in active power control and to improve the transient stability of power systems. Shunt connected controllers govern reactive power and improve the dynamic stability. Static Var Compensators (SVC) control only one of the three important parameters i.e voltage, impedance, and phase angle, that determine the power flow in the AC power system. It has been realized that SVC which is true equivalent of ideal synchronous condenser, is technically feasible with the use of gate turn-off (GTO) thyristor. The SSSC is a recently introduced FACTS controller which has the capability to control all the three transmission parameters (voltage, impedance, phase angle) [1]. The SSSC not only performs the functions of the STATCOM, TCSC, and the phase angle regulator but also provides additional flexibility by combining some of the functions of the controllers. The SVC regulates voltage at its terminal by controlling the amount of reactive power injected into or absorbed from the power system. When system voltage is low, the SVC generates reactive power (capacitive). When system voltage is high, it absorbs reactive power (inductive). SVC is considered as the first generation of shunt connected FACTS devices that have been implemented in power systems to provide fast-acting reactive power and voltage support to the power grid. By incorporating inductive and capacitive branches, SVC is able to regulate the voltage at a chosen bus by supplying or absorbing reactive power.

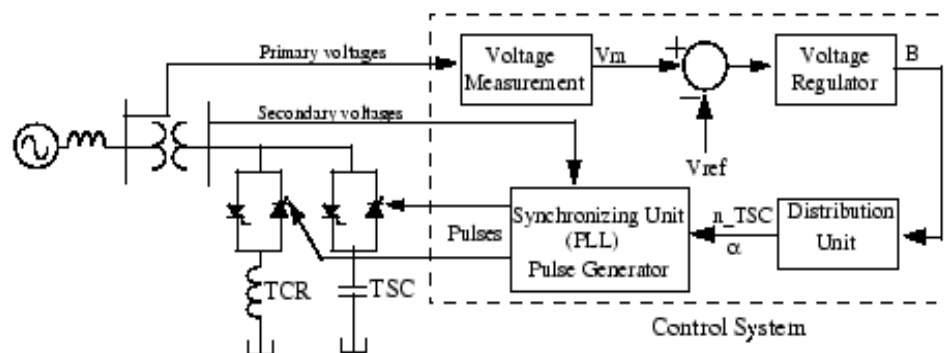


Fig.1. SVC and its control system block diagram

The advantages of simplicity, low losses, low harmonics production and low cost have made SVC to be used extensively compared to other shunt FACTS devices [5]. In fact, many SVCs have been installed at power plants around the world and are considered attractive elements to enhance the performance of power systems. The SVC operates under power oscillation damping control mode to damp inter-area mode of oscillations. A typical structure of the SVC that consists of a Thyristor-Controlled Reactor (TCR), a Thyristor-Switched Capacitor (TSC) and a harmonic filter used to filter the harmonics generated by the TCR is illustrated in Fig.1. Location of the SVC in the power system network is important to dictate its effectiveness. Since the voltage drop along an uncompensated transmission line is the largest at the midpoint, it is ideal to connect the SVC at the middle of the transmission line. The SVC can be operated in two modes: in voltage regulation mode (the voltage is regulated within limits) and in VAR control mode (the SVC susceptance is kept constant). When the SVC is operated in voltage regulation mode, it implements the following V-I characteristics. As long as the SVC susceptance  $B$  stays within the maximum and minimum susceptance values imposed by the total reactive power of capacitor banks  $B_{cmax}$  and reactor banks  $B_{lmax}$ , the voltage is regulated at the reference voltage  $V_{ref}$ .

### III. PROPOSED METHODOLOGY

Proposed control system provides an effective solution for designing controllers applied to systems whose parameters change continuously during operation and no prior knowledge can be obtained of when these changes will take place. By using this type of control scheme, the controller can constantly adapt itself to the current behaviour of the system. The goal of Proposed control is to obtain a knowledge of the properties of a system based on its input and output data. A simple artificial neural network power system stabilizer (ANN-PSS) is presented for a synchronous generator with excitation system connected to the infinite bus through a transmission line. Conventional design techniques use a linearized single machine infinite bus system to design a power system stabilizer (PSS) based on the transfer function between the automatic voltage regulator input and resultant developed electrical torque by the synchronous generator. Because the power system is highly nonlinear, with configurations and parameters that change with time, the conventional PSS cannot guarantee good performance in a realistic operational environment. Therefore, a ANN-PSS has been simulated to improve the system dynamics performance and to adapt the controller's parameters in real time due to any changes in operating conditions using MATLAB Simulink. Since 1989, ANNs methodology has captured interest in electrical power engineering and has promised to ensure effective system performance enhancement [6]. The use of artificial neural networks (ANNs) offers an attractive alternative for the SVC control. The ANNs are able to model on-line nonlinear, MIMO (multiple inputs multiple outputs), and non-stationary systems. The ANNs nature makes them robust, adaptive, optimum and hybrid control techniques with attractive features to power system control [6]. An alternative control approach using the ANN control strategy for SVC to improve the performance of a multi-machine power system. The ANN scheme was trained by on-line unsupervised (self learning) ANN based PID controller using an optimization technique to minimize the system deviations in most common operating conditions. The ANN system consists of one input, one hidden and one output layers for each parameter. The simulation results obtained with ANN-SVC controller is compared with others obtained using conventional PID-SVC controller. These results reveal that the ANN controller is more flexible and robust for the system when subjected to various disturbances in a wide range of operating conditions. The conventional PID controller is designed according to a certain operating point and its parameters are fixed. To overcome the drawbacks of the conventional controllers, ANN strategies are proposed due to its simple structure, adaptability, robustness and considering the power grid nonlinearities. To obtain the optimal values of ANN based PID controller parameters, two ANNs are established to take the place of  $PID\phi$  and  $PIDc$  damping controllers. The inputs to the ANNs are the deviation in the transmission line active and reactive powers and its output is only one PID parameter. So, the proposed ANN construction is repeated three times for each controller parameter.

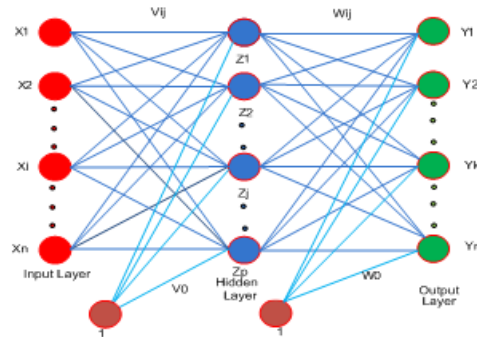


Fig.2. Multi-layer Neural Network (MNN)

#### IV.SIMULATION AND RESULT DISCUSSION

A static var compensator (SVC) is used to regulate voltage on a system. When system voltage is low the SVC generates reactive power (SVC capacitive). When system voltage is high it absorbs reactive power (SVC inductive). The SVC is rated +100 Mvar capacitive and 50 Mvar inductive. The two 500kV Three-Phase Programmable Voltage Source is used to vary the system voltage to observe the SVC performance. The two source voltages of 735 kV are connected by a transmission line through three-phase step-up transformers. The system consists of two output voltage of transformer is 735/16KV equivalents, respectively in each area, connected by a transmission line. The loads in each area having 20MW are so chosen that the real power flow on the transmission line from area 1 to 2. Where the active & reactive power absorbed by the load is a function of the system voltage. System have four buses where Voltage(pu) , current(pu) and reactive power observe

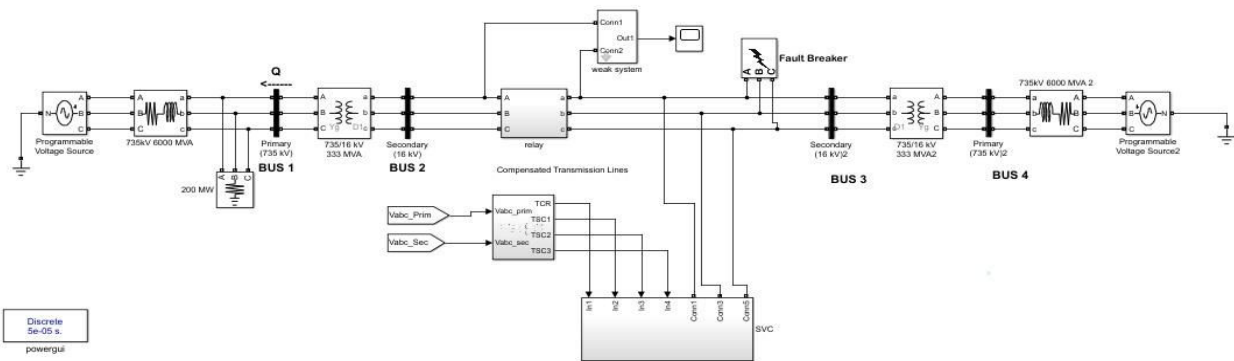


Fig.3. Simulink model of Proposed System

The control system consists of a measurement system measuring the positive-sequence voltage to be controlled. A Fourier-based measurement system using a one-cycle running average is used. 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. a neural network use to obtain desired output.

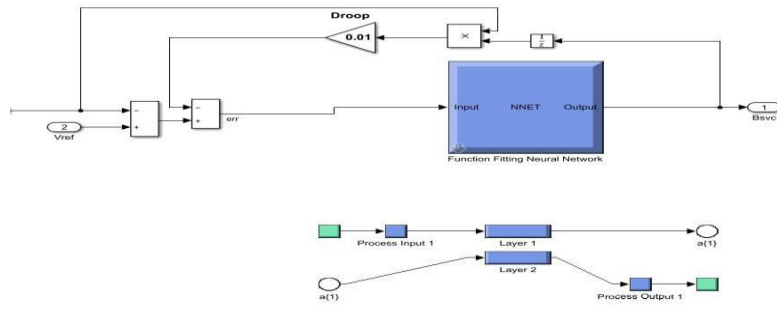


Fig.4. Voltage Regulator system

In this case a LG fault occurs at near bus 3 during 0.5s to 1s as we see here there is no effect in bus voltage and bus current it almost one per unit and vary reactive power as per requirement during fault condition.

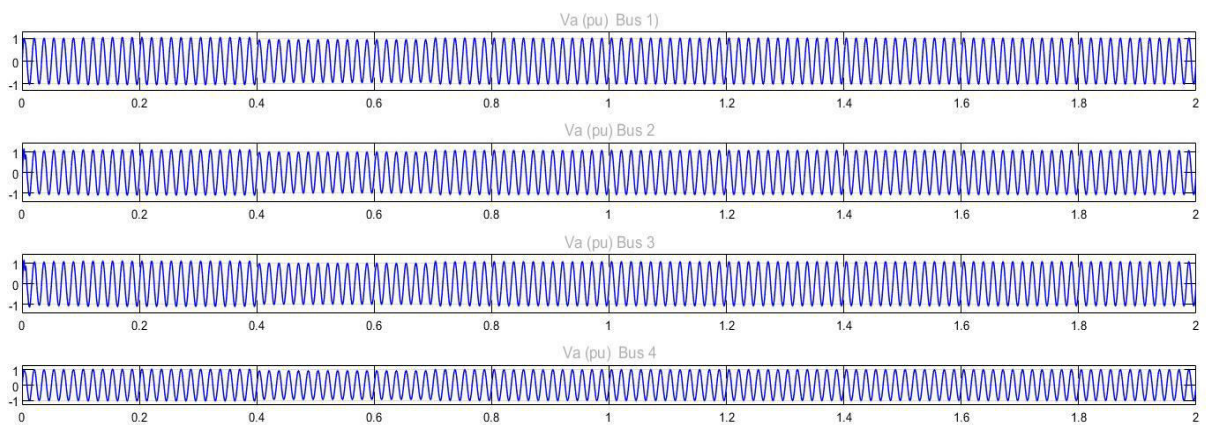


Fig.5 Voltage at each bus with SVC connected and with LG fault

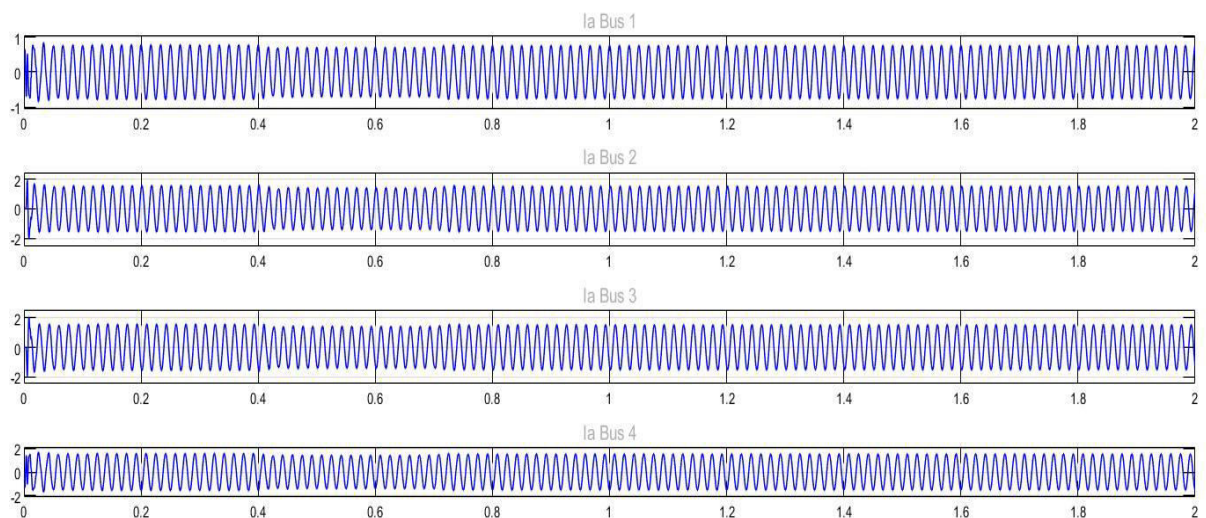


Fig.6. Current at each bus with SVC connected and with LG fault

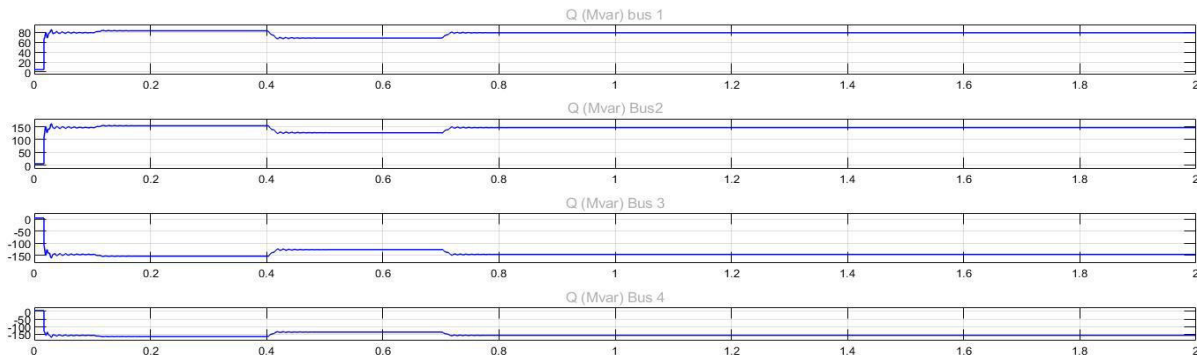


Fig.7. Reactive Power at each bus with SVC connected and with LG fault

During short circuit fault SVC maintain current at each bus as well as voltage by ANN based SVC which provide smooth power flow across system and maintain stability of system during fault condition.

## V.CONCLUSION

The voltage control devices which are ANN based SVC are successfully modeled in the MATLAB/ Simulink. SVC can be used for both inductive and capacitive compensation. When the voltage system is low the SVC generates the reactive power (SVC Capacitive). When the voltage system is high it absorbs the reactive power (SVC Inductive). The results obtained in the research have been analyzed and discussed. The comparison was done in different normal and fault conditions. These prove that the SVC model can be implemented on the transmission line systems, in order to protect the system from voltage collapse and voltage instability phenomenon. The transient response of ANN based SVC are highly efficient for voltage in comparison of other controller. It improves system stability for both steady state & dynamic conditions. All controller parameters have been selected by trial & error methods normally, but here parameters can be selected by Neural network techniques. Those controllers special advantage is that they can be used on any robust multi-machine power system network with very easily & cheaply. Hence it can be concluded that SVC will successfully control the dynamic performance of power system and will effectively regulate the system oscillatory disturbances and voltage regulation of the power system. Simulations carried out confirm that SVC could provide the fast acting voltage support necessary to prevent the possibility of voltage reduction and voltage collapse. The simulation results are shown in figs. The improvement in the system damping with the SVC controller tuned by ANN can be seen from these figs. From these figs it can be concluded that the system with fixed parameters SVC damping controller designed at one load model becomes unacceptable under other load models and may lead the system to instability. While the system is well damped with the ANN based damping controller. These results clearly demonstrate that the ANN based damping controller can provide good damping of the system over a wide range of varying load types, and hence, effectively simulate the control strategy of an adaptive damping controller for SVC.

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