RESEARCH ARTICLE                      OPEN ACCESS

# An Adaptive Power System Stability Enhancement Using Static Synchronous Series Compensator (SSSC)

Nagarjun Donipala[1], R. Suresh Babu[2],

[1]M.Tech Student, J.B Institute of Engineering & Technology (Autonomous), Hyderabad, India.
[2]Professor and I/C HOD in JB Institute of Engineering and Technology (Autonomous), Hyderabad

**ABSTRACT**

In this research we are investigate the controlling and enhancing or modulation power flow in a transmission line using a static synchronous series compensator (SSSC). At present studies it include detailed PWM techniques controlled for SSSC, are conducted in control circuits. In this proposed technique we are study a static synchronous series compensator is used to investigate the device in controlling active and reactive power as well as damping power system oscillations in th transient mode. This SSSC DEVICE IS EQUIPPED WITH A SOURCE ENERGY IN TH dc LINK can observe or supply the active and reactive power to or supply the active and reactive power to or from the line. This application has been done in MATLAB/SIMULINK environment. The simulation results are obtained from a selected bus-2 in two machine power system shows and efficiency of this compensator is one of the facts device as a member in power flow controller to achieve desired value for active, reactive powers and damping oscillations appropriately,

*keywords* -STATCOM, SSSC, UPFC, Voltage Source Converter (VSC), FACTS

## I. INTRODUCTION

Generally nowadays a greater demand has been placed on the transmission network and then to improve demands will rise, because of increasing the number of non utility generators and heightened computation utilities. These utilities need to use their power transmission system more effectively, improve their utilization degree. To reduce the effective reactance of lines by series compensation to a direct approach improve the transmission capability. The stability considerations are limited in the power transfer capability of long transmission lines. Because of electronic switching capabilities to maintain the stability during the transient faults results the power stability is improved.

In this article for stability improvement we investigate the static synchronous series compensator (SSSC) FACTS [1] controllers are preformed. FACTS devices contain a solid state voltage source converter (VSC) it will generate the controllable to alter the current at fundamental frequency. When the injected voltage was kept in quadrature with the line current, can be emulate the inductive or capacitive reactance so as influence the power flow through the transmission lines. The primary purpose of a SSSC to control the power flow in steady state, and it can also improve their stability of power system.

## II. RELATE WORK

These papers to review the design of SSSC and to derive the exact pi-model of the SSSC embedded transmission lines from which to inject the model of using two port networks is presented. The

SSSC also review some of the possible review advantages and uses the SSSC in power system operations. The unified power flow controller is the most versatile FACTS device it allows the independent influence of the active and reactive power flows as well as to control the voltage profile at the same time. The Unified Power Flow Controller (UPFC) is a combination of both STATCOM (Static Synchronous Compensator) and SSSC are connect via a common dc link to allow the bidirectional flow of the power between the series output terminals of the SSSC and shunt the output terminals of the STATCOM.

## III. STRUCTURE OF SSSC

Basically the SSSC consisting of converter with a semiconductor devices having turn off capability to coupling with transformer and capacity. The converters are connected to a power system through a coupling transformer. In that the DC capacitor deliver or provides a DC voltage support for the converter functions and operators are energy storage element [2]. SSSC injects a voltage in series with transmission lines through the series transformer.
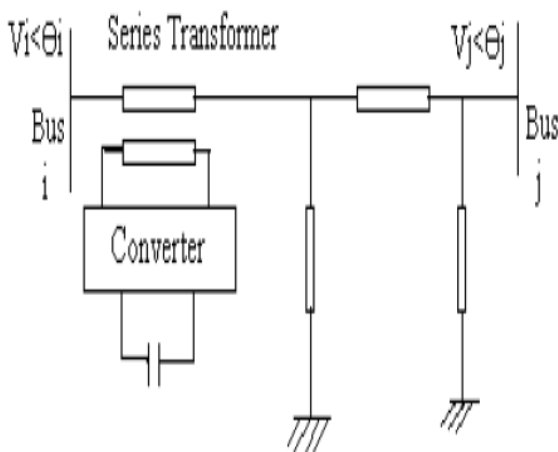
Fig.1 schematic diagram of sssc inserted transmission line.

It connected in series with the transmission line. The three phase transformers are used to connect the compensator in series with the power system. A functional model of SSSC where the dc capacitor has been replaced by an energy storage device as a high energy storage installation to allows an active as well as reactive power exchanges with the AC system. The SSSC output voltage phase displacement of the inserted voltage $V_{pq}$, with respect the transmission line I, to determine the exchange the real and reactive power with AC system [3].

The SSSC working in four quadrants, again assuming a energy storage device connected at the SSSC's input terminal in fig. line current phasor $I_{line}$ is used as a reference phasor while injected SSSC voltage phasor is allowed to rotate the center of the circle defines by the maximum inserted voltage $V_{pq}^{max}$.

$$P = V_{pq}I_{line}\cos\varphi < 0 \qquad P = V_{pq}I_{line}\cos\varphi > 0$$
$$Q = V_{pq}I_{line}\sin\varphi > 0 \qquad Q = V_{pq}I_{line}\sin\varphi > 0$$



$$P = V_{pq}I_{line}\cos\varphi < 0 \qquad P = V_{pq}I_{line}\cos\varphi > 0$$
$$Q = V_{pq}I_{line}\sin\varphi < 0 \qquad Q = V_{pq}I_{line}\sin\varphi < 0$$
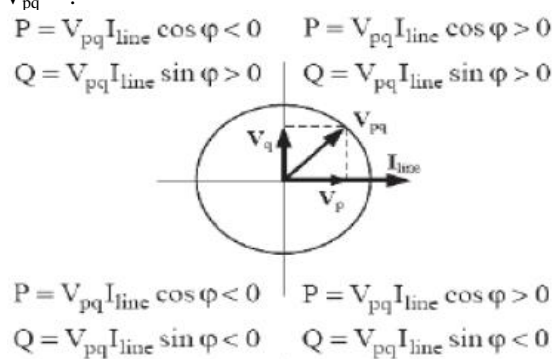
Fig.2 SSSC phasor diagram.

Mathematical, SSSC operation in each of the four quadrants is possible, theoretically the SSSC operation in each of the four quadrants is possible, but there are some disadvantages to inject SSSC voltage due to operating constraints of practical power system

## IV.     METHODOLOGY OF SSSC

SSSC is one of the variable reactance because the injected voltage and current to the model circuit by this devices are changing depends upon the system conditions. To respond the dynamic and transient modifications are created in design, SSSC to utilize the series converters. One of the port is connected to the AC system and the other port is connected to a capacitor and battery within the system to assume DC source as a battery. The dynamic changes in this system will be occurred [4], in SSSC circuit works such that according to the control model circuit the energy of battery will be converted to the AC from converter and then injecting the voltage circuit changes will be damped appropriately. The active and reactive power of BUS2 is calculated using their voltage and current in dq0 references and compared with the determined reference and produced error signal is given to the PI controllers. We are adjusting the parameters of the PI controllers, trying to achieve the zero signal error, such that power can follow the reference powers precisely. Then the outputs of the controllers are transformed to the abc reference voltage given to the PWM.

## V.     SSSC MODELING

Dynamic performance of SSSC is presented by a real time voltage and current signals. Bu using MATLAB software the system has been obtained in Fig.3. In this model circuit SSSC has been utilized to control the power flow in the 500 KV transmission systems. The system which has been made like a ring mode consisting of 4 buses (B1 to B4) are connected to each other through the three phase transmission lines L1, L2-1,L2-2, and L3 with the length of 280,150,150, 50 km respectively. The system has been supplied by two power plants with the phase to phase voltage equal to 13.8 kv.

Table 1
Obtained Results from the simulations

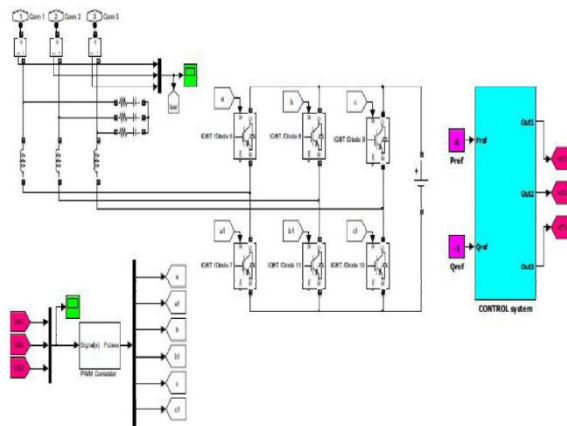| BUS NO | VOLTAGE (Pu) | CURRENT (Pu) | P (Pu) | Q (Pu) |
|---|---|---|---|---|
| 1 | 1.007 | 13.5 | 20.06 | -3.76 |
| 2 | 1.007 | 6.7 | 9.95 | -1.81 |
| 3 | 1.002 | 9.8 | 14.84 | -0.48 |
| 4 | 1.015 | 5.5 | 8.45 | -0.59 |

Fig.3.The convertor of SSSC



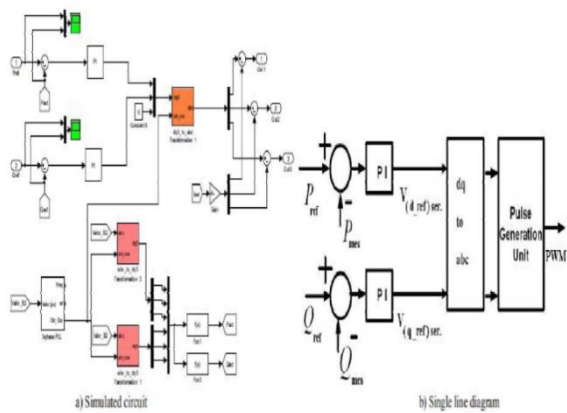a) Simulated circuit      b) Single line diagram

Fig.4.The control circuit of SSSC

In this model the active and reactive power injected by power plants 1 and 2 to the power system are presented in per unit by using the base parameters Sb=100MVA and Vb=500KV, which active and reactive powers of power plants 1 and 2 are (24-j3.8) and (15.6-j0.5) in per unit, respectively.

## VI. SIMULATION RESULTS

In this proposed initially the power system with two machines and four buses has been simulated in MATLAB/ SIMULATION environment and then powers and voltages in all buses have been shown in fig.5. The results have been given in Table 1. We are obtained the results through bus-2 has selected as a user bus to which the SSSC is installed. In this application we concentrate on the simulation results have been focused on bus-2 in model simulation.
Table 1: Obtained Results from the simulations.

**CASE STUDIES**
**5.1.BUS-2 PARAMETERS WITHOUT SSSC**
Variations in current, voltage, active and reactive powers of bus-2 have been obtained in real time. We observed fig.5.1 at first the large loads of the system active power of bus-2 got oscillations keep continuing for 3 seconds. This controlling system in

power plants 1 and 2 such as governor, PSS and other stabilizing all devices are used for damping these oscillations.
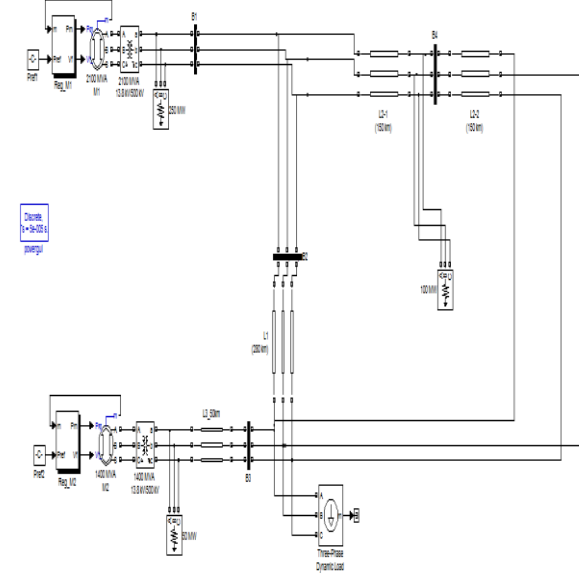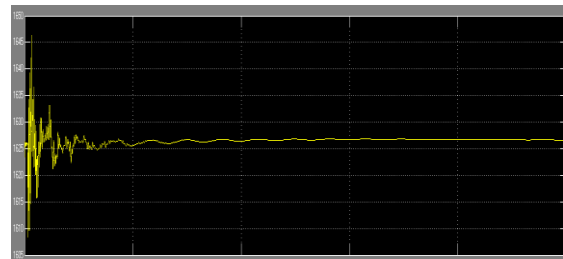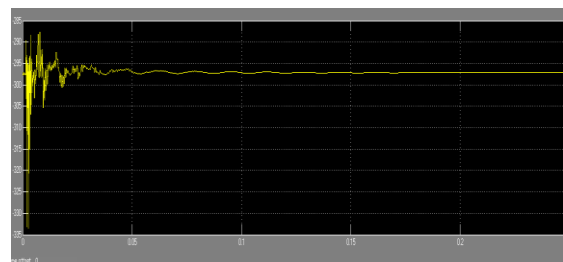


Fig.5.Configuration of two machine power system.



5.1 Active Power of Bus-2 without the installation of SSSC



5.2 Reactive power of Bus-2 without the installation of SSSC.

Then we observe the reactive power of bus-2 got the oscillations at the first and then will damp sufficiently. In these oscillations amplitude the active power is more than that of reactive power, so the ohmic parts of loads of systems are much more. Then in fig.6.1.3 after transient mode is created in the system in that we are measured voltage and current waveforms of bus-2 got closer to the sinusoidal waveforms.
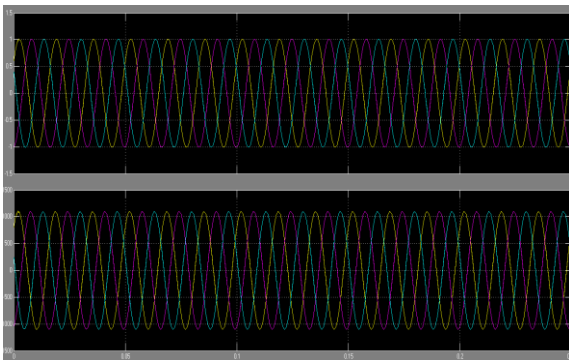
Fig.5.3 Current and voltage of Bus-2 without the installation of SSSC.

## 5.2.PARAMETERS WITH SSSC

In this transmission model circuit fig.6, SSSC has been placed between bus-1 and bus-2 and the main goal is achieving the following active and reactive power.
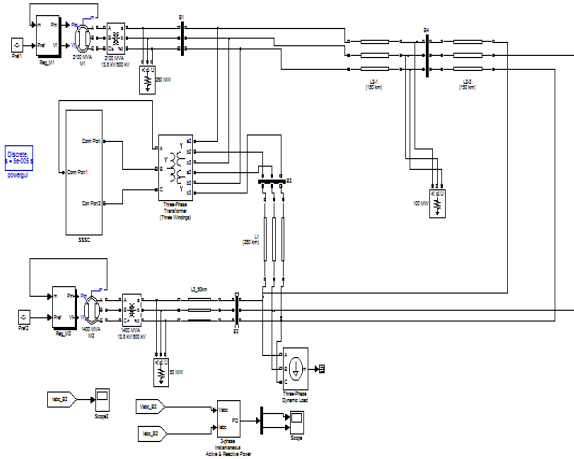


Fig.6 .Two Machine systems with SSSC

The main role of SSSC is controlling active and reactive powers [5]; beside these SSSC could fairly improve the transient oscillations of the system. After insertion of the SSSC, besides to controlling the power flow in bus-2 we want to keep the constant voltage value in 1 per unit, hence the power flow is done in the presence of SSSC and the simulation results are as follows.
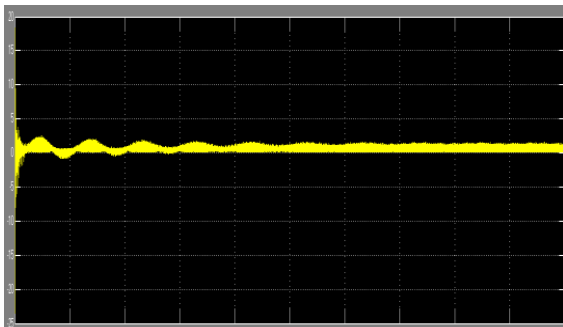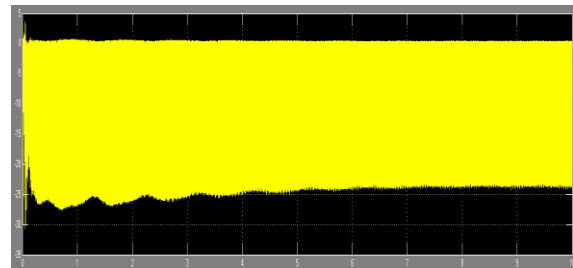


Fig.6.1.Active power of bus-2 in the presence of SSSC



Fig.6.2.Reactive power of bus-2 in the presence of SSSC

According the installation of the SSSC, active power damping time will be less than the mode without SSSC and it will be faster damped [6]-[8]. And also reactive power damping time will be reduced and system will follow the reference value with acceptable error.
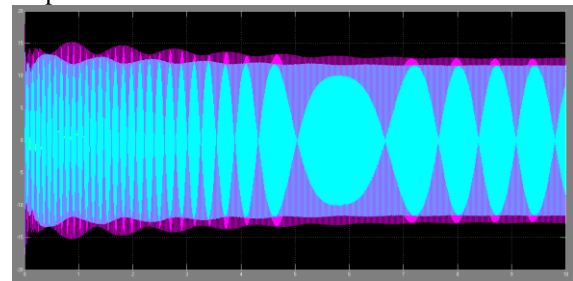


Fig.6.3 Current of the Bus-2 in the presence of SSSC.

After that the current of bus-2 in the presence of SSSC after transient mode will be in the form of sinusoidal form.

## VII. CONCLUSION

In our proposed method the SSSC is a capable of controlling the flow of power at a particular point in the transmission line. And also it observed that the SSSC to inject a fast active changing voltages in series with the line irrespective of the phase and magnitude of the line current. In this research the SSSC is used to damping the power oscillation on a grid power following a three phase fault based on obtained simulation results and the performance of the SSSC has been used in a simple two machine system easily selected bus-2 and this SSSC application will be extended in future research to a complex and multi machine system to investigate the problems related to the various schemes of power oscillation in the power system.

## References
[1] M. Faridi , H.Maeiiat, M. Karimi, P. Farhadi and H. Mosleh (2011) "power System Stability Enhancement Using Static Synchronous Series Compensator (SSSC)" IEEE Transactions on power system

[2] Sandeep Gupta, R. K. Tripathi (2010) "Voltage Stability Improvement in Power

Systems using Facts Controllers: State-of-the- Art Review". IEEE Transactions on Power System, pp.I-8.

[3]    H. Taheri, S. Shahabi, Sh. Taheri and A. Gholami (2009) "Application of Synchronous Static Series Compensator (SSSC) on Enhancement of Voltage Stability and Power Oscillation Damping", IEEE Transactions on Power System, pp. 533-539

[4]    Abido M. A. (2009), "Power System Stability Enhancement Using Facts Controllers: A Review", The Arabian Journal for Science and Engineering, Volume 34, pp. 153-172.

[5]    B.N. Singh, A. Chandra, K.AI-Haddad and B. Singh (1999) "Performance of sliding-mode and fuzzy controllers for a static synchronous series compensator", IEEE proceedings, Volume 146, No.2, pp. 200-206.

[6]    Sen K K (1998), "SSSC-Static Synchronous Series Compensator: Theory, Modeling and Publications", *IEEE Trans. Power Delivery*, Vol. 13, No. 1, pp. 241-246.

[7]    Singh B N, Chandra A, Al-Haddad K and Singh B (1999), "Performance of Sliding-Mode and Fuzzy Controllers for a Static Synchronous Seriescompensator", IEEE Proceedings on the No. 19990072, IEEE.

[8]    Wang F (1999), "Design of SSSC Damping Controller to Improve Power System Oscillation Stability", IEEE.

## AUTHOR

**Mr.Nagarjun Donipala** Received B.Tech degree from JNTUH, INDIA and presently he is pursuing M.Tech in ELECTRICAL POWR SYSTEMS from JBIET (Autonomous), His areas of Interests are power Systems, Machines.

**Mr.R.Suresh Babu** Completed B.Tech from NAGARJUNA University, M.Tech from JNTU KAKINADA & pursuing Ph.d from ANU and currently working as Associate Professor in J.B. Institute of Engineering and Technology (Autonomous), Hyderabad , India.