International Journal of Research in Advent Technology, Vol.2, No.10, October 2014
E-ISSN: 2321-9637

Improvement of Power Flow and Transient behaviour of a Two Machine Power System Using SSSC

Daljeet Kaur[1], Chintu Rza Makkar[2], Shivani Mehta[3]
Department of Electrical Engineering D.A.V.I.E.T., Jalandhar, Punjab, India[1, 2, 3,]
Student (M.Tech), Assistant Professor, Assistant Professor[1, 2, 3,]
Email: kaurdaljeet88@gmail.com[1], chinturza78@gmail.com[2], shivanimehta7@gmail.com[3]

Abstract- Flexible AC transmission system called FACTS is a well known term for higher controllability in power systems by means of power electronic devices. In this paper the power system behaviour of a two machine model of a power system using a series FACTS device called Static Synchronous Series Compensator (SSSC) is presented. The simulation results ensure the advantages of applying SSSC in the power system by improving the power flow and the transient behaviour under a severe three phase fault.

Index Terms- Flexible alternating current transmission system; FACTS, Static Synchronous Series Compensator; SSSC, Voltage source converter; VSC, Rotor angle Deviation, Power flow

1. INTRODUCTION

Modern power system has been converted into a convoluted network because of increasing electric power demands in the last few years. It consists of various generators, transformers, transmission lines and variety of loads. So power systems are intended to operate proficiently to supply power on demand to load centers with high reliability [1]-[3]. The generating stations are repeatedly located at distant locations for economic, environmental and safety reasons. A large power system has several interconnections and bulk power transmissions over long distances [1]. Due to which low frequency inter area oscillations occur which makes system susceptible to cascading failures. The power oscillations and power flow of a power system can vary under normal and faulty conditions. It is very essential to improve the power flow and damp out the power oscillations to maintain the system stability [2]-[4]. Many different methods have been anticipated to damp the oscillations in the power system. For many years, power system stabilizer (PSS) has been used as one of the conventionally devices for oscillations damping. It is reported that during some operating conditions, PSS may not mitigate the oscillations effectively. So other efficient alternatives are required in addition to PSSs [6].

Flexible Alternating Current Transmission Systems (FACTS) are new devices originated from recent innovative technologies that are capable of improving power flow, altering voltage, impedance or phase angle at particular points in power system [3]. These devices offer high speed, reliable control competency, more adaptable and flexible approach to control the power system in a very essential way. FACTS controllers provides stimulating capabilities such as power flow control, damping of oscillations in the power system, reactive power compensation and voltage regulation. One of the new series FACTS devices is Static Synchronous Series Compensator (SSSC). It is used to control the power flow through transmission lines and avoid overloads during network contingencies [7]. Other applications of the SSSC are damping of electromechanical oscillations and prevention of loop-flows. The static synchronous series compensator (SSSC) is based on a solid-state voltage source converter, which generates a controllable ac voltage in quadrature with the line current. Thus SSSC emulates as an inductive or capacitive reactance. Consequently SSSC controls the power flow in the transmission lines [8].

In this work a simulink model of a two machine power system with SSSC is developed. Power flow and Transient behaviour of the developed system is analyzed. Static synchronous series compensator (SSSC) is used to investigate its effect in controlling power flow and rotor angle deviation of two machines of the power system.

This research paper is organized as: In section 2 there is the description of the Static Synchronous Series Compensator (SSSC). We design a simulink model of a two machine power system with SSSC, which is described in section 3. In section 4 simulation results and comparison are discussed.

2. STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)

In general, FACTS controllers can be alienated as, series controllers, shunt controllers, combined series-series controllers and combined series-shunt controllers. SSSC is a series FACTS controller. The series controller could be a variable impedance source such as capacitor, reactor etc or a power electronic based variable source. SSSC is one of the modern FACTS devices for power transmission series compensation. It can be considered as a synchronous voltage source as it can inject an almost sinusoidal voltage of variable and controllable amplitude and phase angle in series with a transmission line [6].

The deviation of injected voltage is achieved by means of a Voltage sourced convertor, which is connected on the secondary side of a coupling transformer. The VSC utilizes forced-commutated power electronic devices like (GTOs, IGBTs or IGCTs) to synthesize a voltage V_conv from a DC voltage source as shown below.

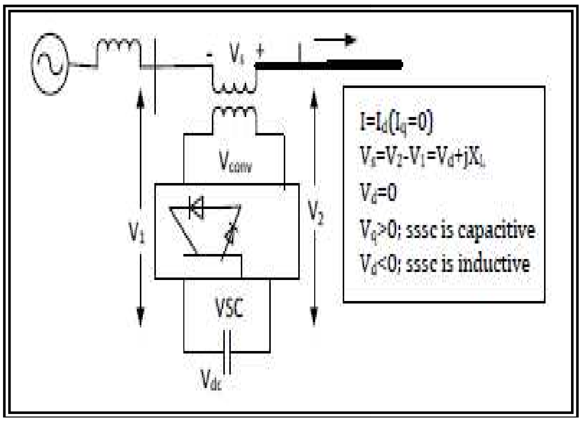

Fig 2.1: Connection diagram of SSSC with transmission line

A capacitor connected on the DC side of Voltage source converter (VSC) acts as a DC voltage source. A small active power is drawn from the line to maintain the capacitor charged and to provide transformer and VSC losses. Thus injected voltage Vs is practically 90° (degree) out of phase with current I. In the control system block diagram Vd_conv and Vq_conv designate the components of converter voltage Vq_conv, which are in phase and quadrature with current respectively.

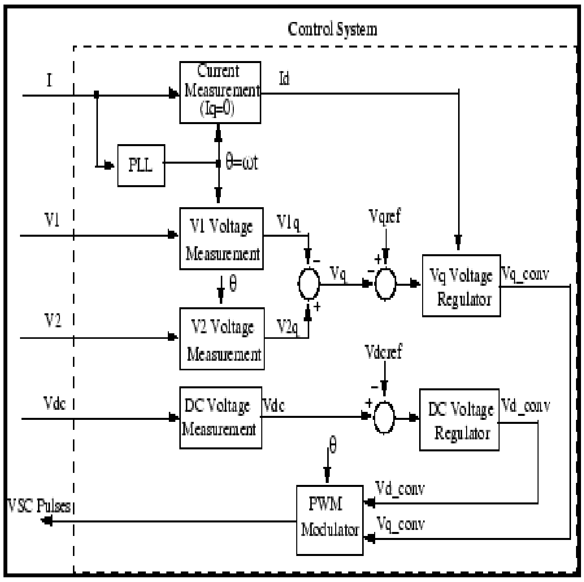

Fig 2.2: Control system block diagram of SSSC

Most of the injected voltage, which is in quadrature with the line current, provides the effect of inserting an inductive or capacitive reactance in series with the transmission line [8]. The variable reactance controls the electric power flow in the transmission line.

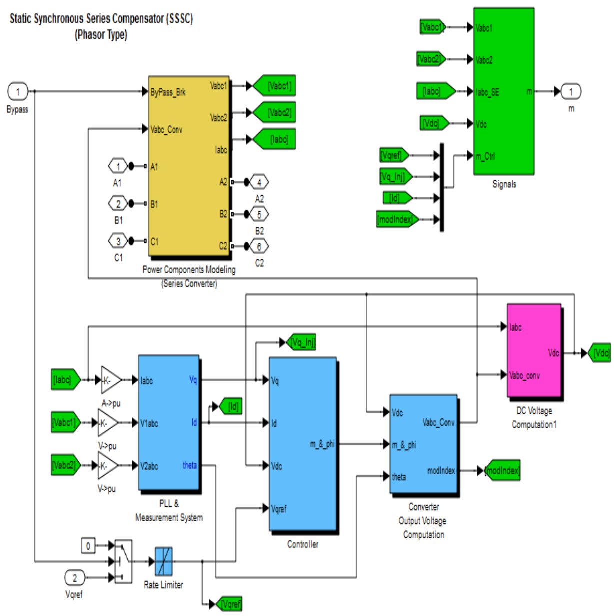

Fig 2.3: SSSC Controller

3. SIMULINK MODEL OF A TWO MACHINE POWER SYSTEM WITH SSSC

In this research paper, we develop a simulink model of a two machine power system using a series FACTS device called as Static synchronous series compensator (SSSC). SSSC is used to control the power flow and to improve the transient behaviour in a 500 kV /230 kV transmission system.

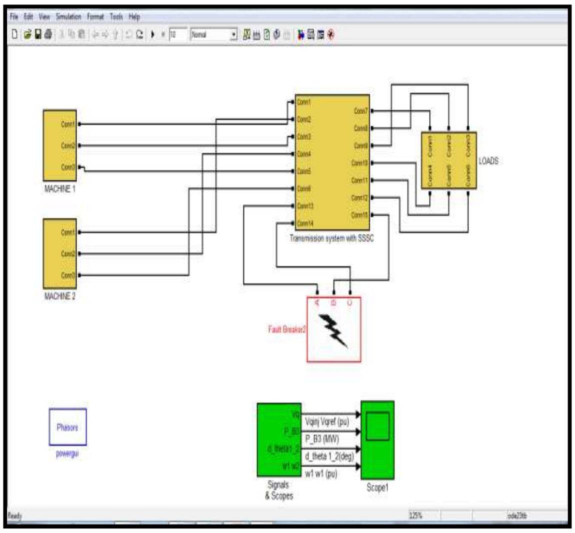

Fig 3.1: Matlab/Simulink model of two machine power system with SSSC (FACTS device)

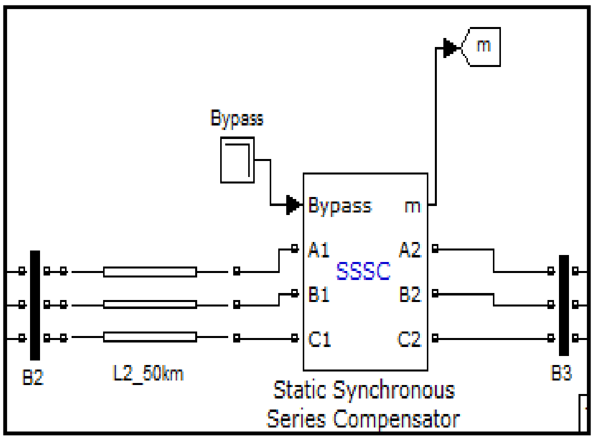

Fig 3.2 Matlab/Simulink Block of SSSC connecting in series with the transmission line (L2)

The system connected in a loop configuration, consists of five bus interconnected through three transmission lines and two transformer banks. The generation plant model comprises a speed regulator, an excitation system as well as a power system stabilizer.

4. SIMULATION RESULTS

SSSC is added in the Simulink model to increase the transmission capacity after a three phase fault, which occur on the bus 1 of the power system model. Waveforms of rotor angle deviation of two machines, power flow and their results with and without SSSC are shown below which ensures the advantage of applying FACTS device (SSSC) in the circuit by increasing the power flow and transient stability under a severe three phase fault occurring at 0.1 seconds and clearing at 0.2 seconds.

Table 4.1: Results of rotor angle deviations of two machines with and without SSSC under a three phase fault

	Time (sec)	First Peak (degree)
Without SSSC	0.35	- 3.70°
With SSSC	0.32	- 4.86°

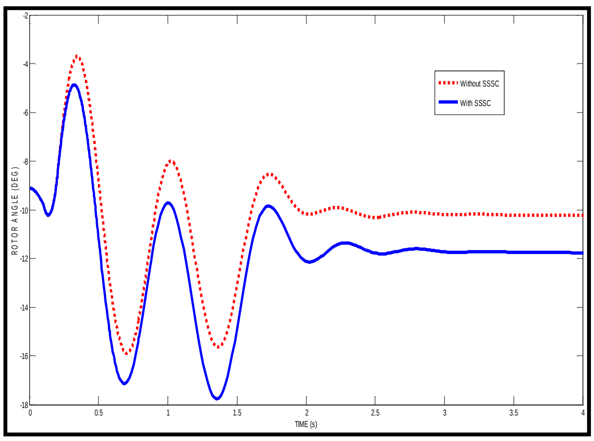

Fig 4.1 Comparison of rotor angle deviations of two machines with and without SSSC for a three phase fault

Table 4.2 Results of Power Flow of line (L2_50km) under three phase fault

	Time (sec)	Power Flow (MW)
Without SSSC	2.4	503
With SSSC	2.4	624.3

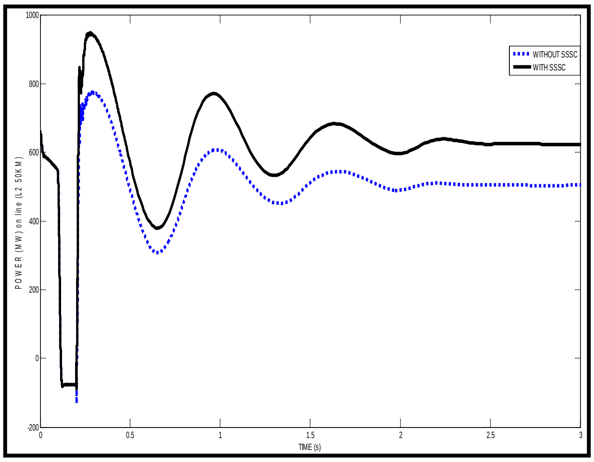

Fig 4.2: Comparison of Power Flow of line (L2_50km) of simulink model with and without Static Synchronous Series Compensator (SSSC) under three phase fault

5. CONCLUSION

This paper presents the power system behaviour of a two machine matlab model of a power system. Response of rotor angle deviation and improvement of power flow are shown. Simulink results show that there is a considerable improvement in power flow of the developed simulink model by using series FACTS device, Static synchronous series compensator (SSSC). The rotor angle of the machines is also decreased. Hence SSSC gives better results by decreasing the rotor angle peak and increasing the power flow.

REFERENCES

[1] R. Mihalic, P. Zunko and D. Povh, 1996, “Improvement of Transient Stability using Unified Power Flow Controller,” IEEE Transactions on Power Delivery, 11 (1), pp. 485-491.

[2] D.V.N. Anantha1, B. Vijaya Lakshmi 2, Performance analysis of Power oscillation damping using SSSC FACTS device, International Journal of Advanced Research in Electrical, Vol. 2, Issue 11, November 2013

[3] K. Kalyan Kumar, V. Shararth Babu, M. Hari Babu, R. Bhaskar, Performance comparison of SVC and SSSC with POD controller for Power System Stability, IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE, Volume 6, Issue 2 (May. - Jun. 2013), PP 28-37

[4] Falehi, A.D. ; Rostami, M. ; Doroudi, A., Coordinated design of PSSs and SSSC-based damping controller based on GA optimization technique for damping of power system multi-mode oscillations , Power Electronics, Drive Systems and Technologies Conference (PEDSTC), 2011 2nd , IEEE Conference Publications.
Publication Year: 2011, Page(s): 199 - 204

[5] Habibur Rahman1,Jewel Rana2,Harun-Or-Rashid, Power System Stability Improvement By UsingSSSC With Power System Controller, International Journal of Science, Engineering & TechnologyResearch(IJSETR)Volume 1, Issue 6,December- 2012

[6] Chandrakar, V.K. ; Kothari, A.G., Comparison of RBFN based STATCOM, SSSC and UPFC Controllers for Transient Stability improvement, Power Systems Conference and Exposition, 2006. PSCE '06. 2006 IEEE PES IEEE Conference Publications, Publication Year: 2006, Page(s): 784 - 791

[7] K.R. Padiyar, Nagesh Prabhu “Investigation of SSR characteristics of unified power flow controller” Department of Electrical Engineering, Indian Institute of Science, Bangalore 560012, India.

[8] Weihao Hu ; Chi Su ; Jiakun Fang ; Zhe Chen, Comparison study of power system small signal stability improvement using SSSC and STATCOM , Industrial Electronics Society, IECON 2013 - 39th Annual Conference of the

IEEE , IEEE Conference Publications Publication Year: 2013 , Page(s): 1998 – 2003

[9] Zareiegovar, G. ; Shayeghi, H. ; Sakhavati, A. ; Nabaei, V., A new scheme to control SSSC in interconnected power systems , Environment and Electrical Engineering (EEEIC), 2010 9th International Conference , Publication Year: 2010 , Page(s): 202 – 205

[10] Taheri, H. ; Shahabi, S. ; Taheri, S. ; Gholami, A., Application of Synchronous Static Series Compensator (SSSC) on enhancement of voltage stability and power oscillation damping , EUROCON 2009, EUROCON '09. IEEE, IEEE Conference Publications, and Publication Year: 2009Page(s):533-539

[11] Poshtan, M. ; Singh, B.N. ; Rastgoufard, P., A Nonlinear Control Method for SSSC to Improve Power System Stability, Power Electronics, Drives and Energy Systems, 2006. PEDES '06. International Conference, Publication Year: 2006, Page(s): 1 - 7

[12] Chandrakar, V.K. ; Kothari, A.G., Comparison of RBFN based STATCOM, SSSC and UPFC Controllers for Transient Stability improvement, Power Systems Conference and Exposition, 2006. PSCE'06. 2006 IEEE PES IEEE Conference Publications, Publication Year: 2006, Page(s): 784 – 79

[13] Ghaisari, J. ; Bakhshai, A. ; Jain, P.K. A nonlinear control approach to increase power oscillations damping by means of the SSSC, Power Engineering Society General Meeting, 2005. IEEE Conference Publications, IEEE Publication Year: 2005, Page(s): 1601 - 1608 Vol. 2

[14] Yap, E.M. ; Al-Dabbagh, M. ; Thum, P.C., Applications of FACTS Controller for Improving Power Transmission Capability , TENCON 2005 2005 IEEE Region 10, IEEE Conference Publications ,Publication Year: 2005 , Page(s): 1 - 6