COMPARISON OF SVC AND TCSC FOR TRANSIENT STABILITY ENHANCEMENT OF MULTI-MACHINE 14 BUS SYSTEM

Mohini[*1], Kiran Rani[2], Urmila Bainsla[3], Neha Saxena[4]

[1,2,3,4] Research Scholar/YMCA university of Science and Technology, Faridabad, India

[*]E-mail of the corresponding author: ahlawatmohini@gmail.com

Abstract— As the power system is very vast and it is having variety of loads connected to it, the chances of occurring transients are large. Transients occur in a power system due to a fault on transmission lines, loss of a large load or sudden loss of generation. The ability of a power system to maintain synchronism when subjected to a severe transient disturbance is called transient stability. The control of transient stability plays a significant role in ensuring the stable operation of power system when the large disturbances and faults occur in the power system .To improve the transient stability various FACTS devices are used. In this paper Static Var Compensator (SVC) and Thyristor Controlled Series Compensator (TCSC) are used to improve the power system transient stability in a multi- machine 14 bus system using Matlab/Simulink. The comparison of series compensated FACTS device TCSC and shunt compensated FACTS device SVC is also shown.

Keywords— Active power, Flexible AC Transmission Systems (FACTS), Matlab/Simulink, Static Var Compensator (SVC), Power system stability, Thyristor Controlled Series Compensator (TCSC), Transient Stability

INTRODUCTION

The network of power system is very complex which is made up of numerous generators, transmission lines, variety of loads and transformers. Because of increasing power demand some transmission lines are more loaded and a result the problem of transient stability can become a transmission limiting factor [1]. The ability of a power system to maintain synchronism when subjected to a severe transient disturbance is called transient stability [2]. Power system stability can be improved through the application of advanced controlled technologies. Power electronics has developed the Flexible AC Transmission System (FACTS). The FACTS devices can be used to control impedance, voltage, phase angle etc. of high voltage AC lines. By using FACTS devices power system stability can be improved satisfactory [3]. Thyristor Controlled Series Compensation (TCSC) is a type of FACTS device which can provide advantages like damping power system oscillations and controlling power flow in the line. TCSC also in improves the power transfer capability, voltage stability and supplying reactive power demand. SVC is a type of FACTS device which can provide advantages like improving system voltage, damping power system oscillations and controlling power flow in the line. SVC is very efficient in improving the overall transient stability of the system [8].

STATIC VAR COMPENSATOR (SVC)

SVC is basically a shunt connected variable var generator whose output is adjusted to exchange capacitive or inductive current to system. SVC regulates voltage at required bus by controlling amount of reactive power injected into or absorbed from power system. Most widely used svc configuration is fixed capacitor- thyristor controlled reactor (FC-TCR). In this a fixed capacitor is connected in parallel with thyristor controlled reactor. The effective reactance of FC-TCR is varied by firing angle control of anti-parallel thyristors. The firing angle is controlled through a proportional-integral (PI) controller in such a way that voltage of bus where SVC is connected is maintained at reference value [11].

THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC)

A TCSC is a series-controlled capacitive reactance that can control the continuous power flow on AC lines. The principle of variable-series compensation is to increase the fundamental-frequency voltage across a fixed capacitor in a series compensated line by varying the firing angle α . This increased voltage, changes the effective value of the series-capacitive reactance [4].

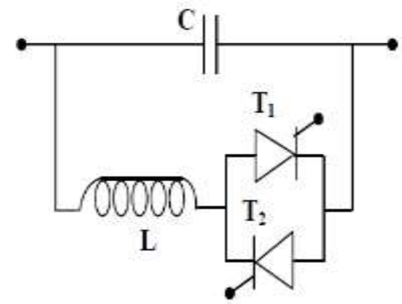

Figure1. A Simple diagram of TCSC device

The basic diagram of TCSC is shown in Figure1. This figure shows that the series compensating capacitor is shunted by a Thyristor Controlled Reactor (TCR). To obtain the desired operating characteristics and voltage ratings various such basic compensators can be connected in series. At the fundamental system frequency TCR is a continuously variable reactive impedance which is controlled by delay angle α . The steady state impedance of the TCSC now becomes as that of a parallel LC circuit, which consists of a fixed capacitive impedance, X_C and a variable inductive impedance, $X_L(\alpha)$. So, the impedance of TCSC becomes $X_{TCSC}(\alpha) = (X_C * X_L)/(X_L(\alpha) - X_C)$ .Where $X_L(\alpha) = X_L * \pi/(\pi - 2\alpha - \sin\alpha)$, $X_L \le X_L(\alpha) \le \infty$ .Whereas, $X_L = wL$ and α is the delay angle measured from the crest of the capacitor voltage[13][14] The TCSC can be operated in either inductive region or capacitive region according to the delay angle α .If $90 < \alpha < \alpha_{L\lim}$ it means TCSC will operate in inductive region, and if $\alpha_{C\lim} < \alpha < 180$ it will operate in capacitive region. For $\alpha_{L\lim} < \alpha < \alpha_{C\lim}$ it will operate in resonance region [7].

SIMULATION MODEL AND RESULTS WITH SVC

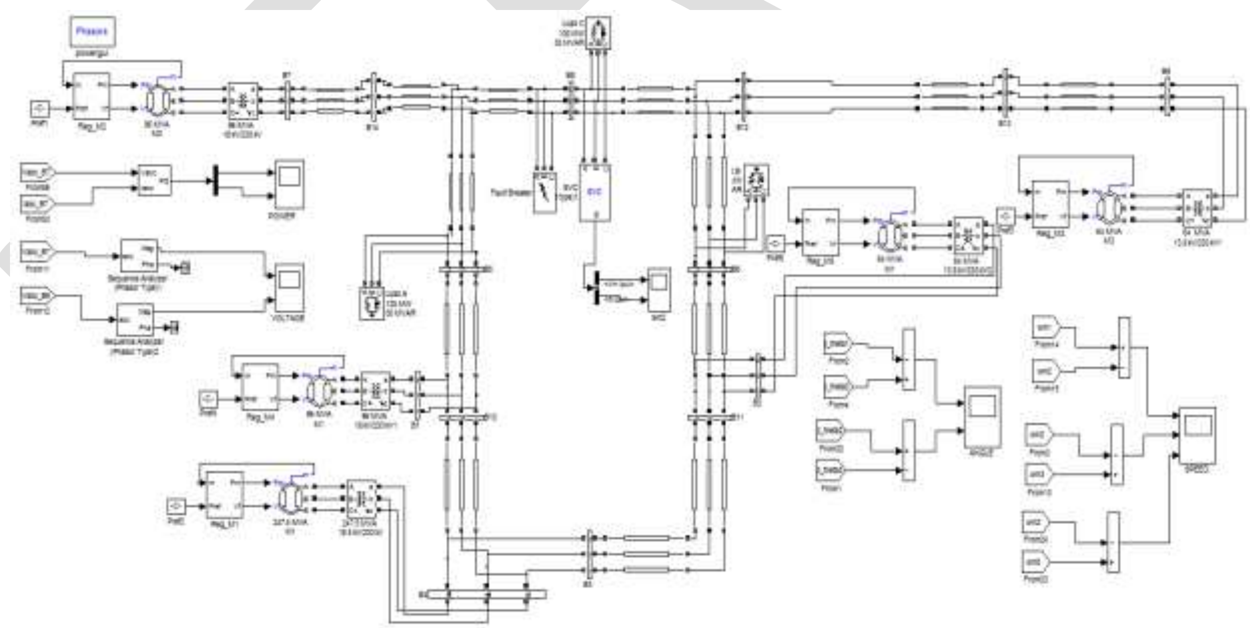

Figure2. Simulink model of a 14 bus system with five generating units and fault with SVC

Simulink model of a fourteen bus system with five generating units and fault is shown in Fig 4.1 which is simulated in MATLAB. Five generators of 96MVA, 64MVA, 247.5MVA, 64MVA and 96MVA are used and a total load of 315MW and 115MVAR is used. A single phase fault is connected between bus8 and bus14. Various measurements blocks and scopes are connected to observe the variation of voltage, active power, reactive power, difference of rotor speeds oscillations and difference of rotor angle oscillations [5].

This Figure 2 shows that when a fault occurs in a Fourteen bus system with five generating units without SVC. The effect of fault of very short duration which is applied between 5.1second to 5.4 seconds is observed on voltage, active power, reactive power, difference in rotor speed oscillations and difference in rotor angle oscillations is see [12].

Output waveforms

The comparison of output waveforms without SVC and with SVC are observed as:

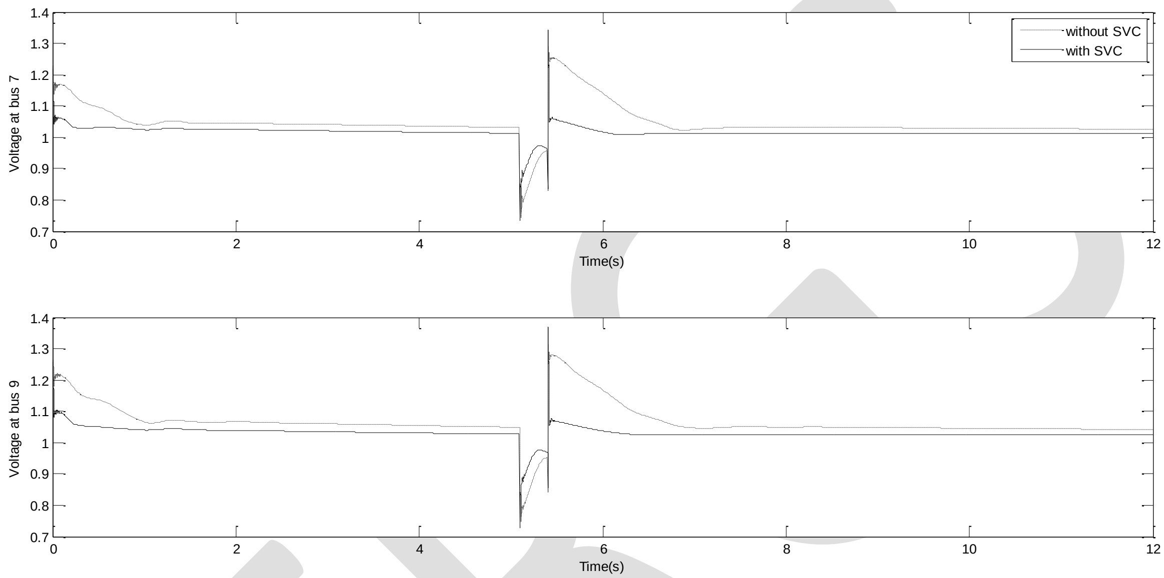

Figure3. Comparison of output waveforms of Voltages at bus 7 and bus 9 when fault occurs without SVC and with SVC

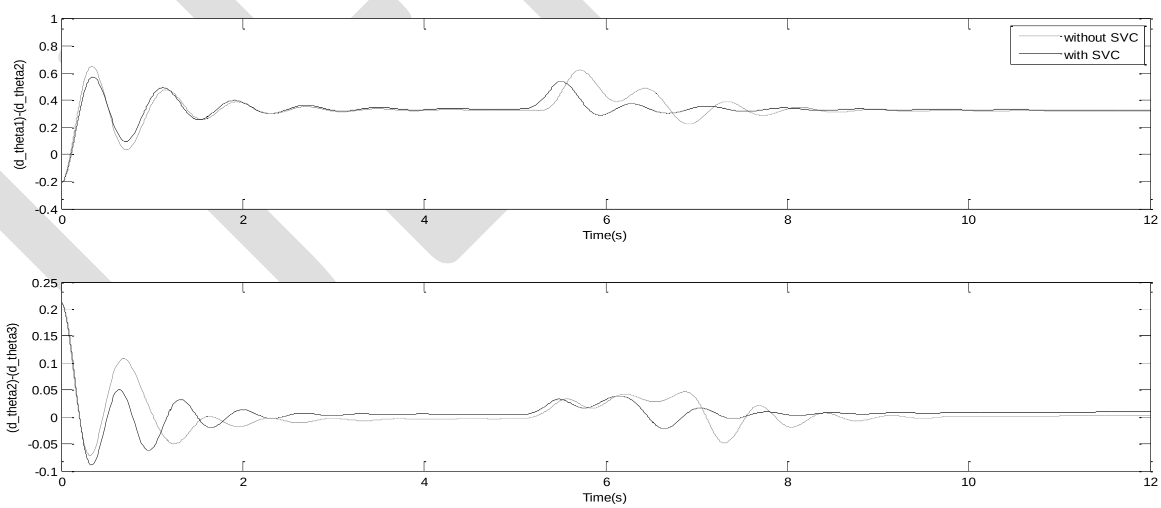

Figure4. Comparison of output waveforms of difference in rotor angle oscillations when fault occurs without SVC and with SVC

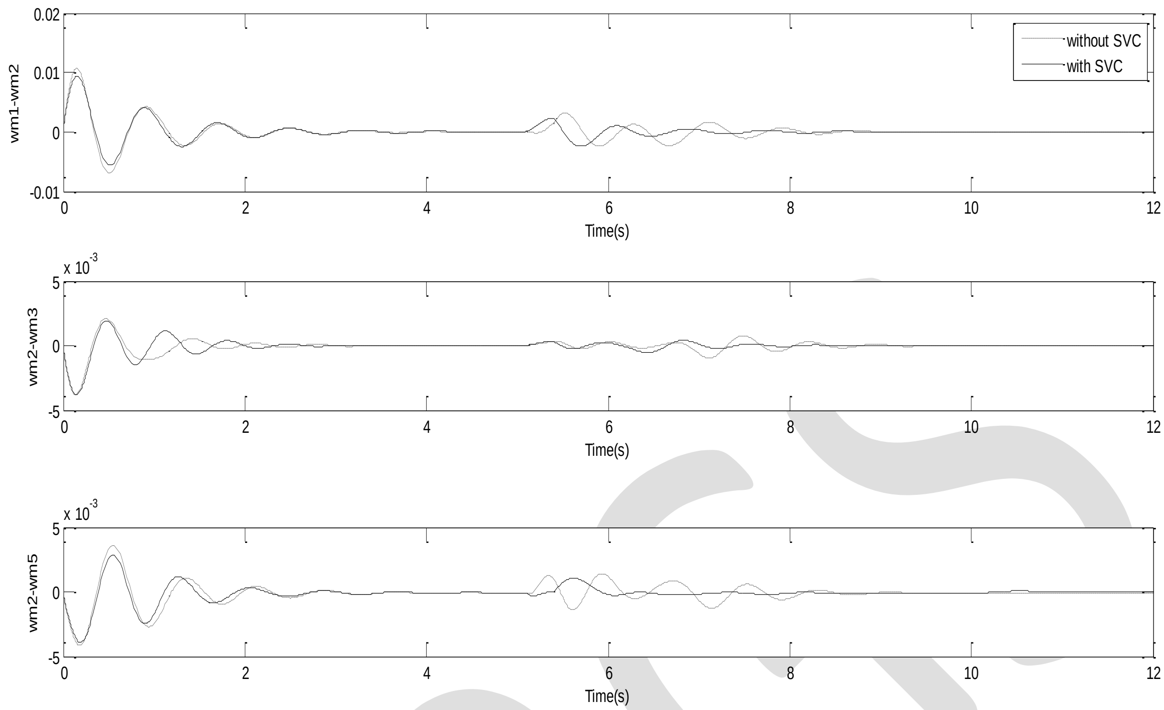

Figure5. Comparison of output waveforms of difference in rotor speed oscillations when fault occurs without SVC and with SVC

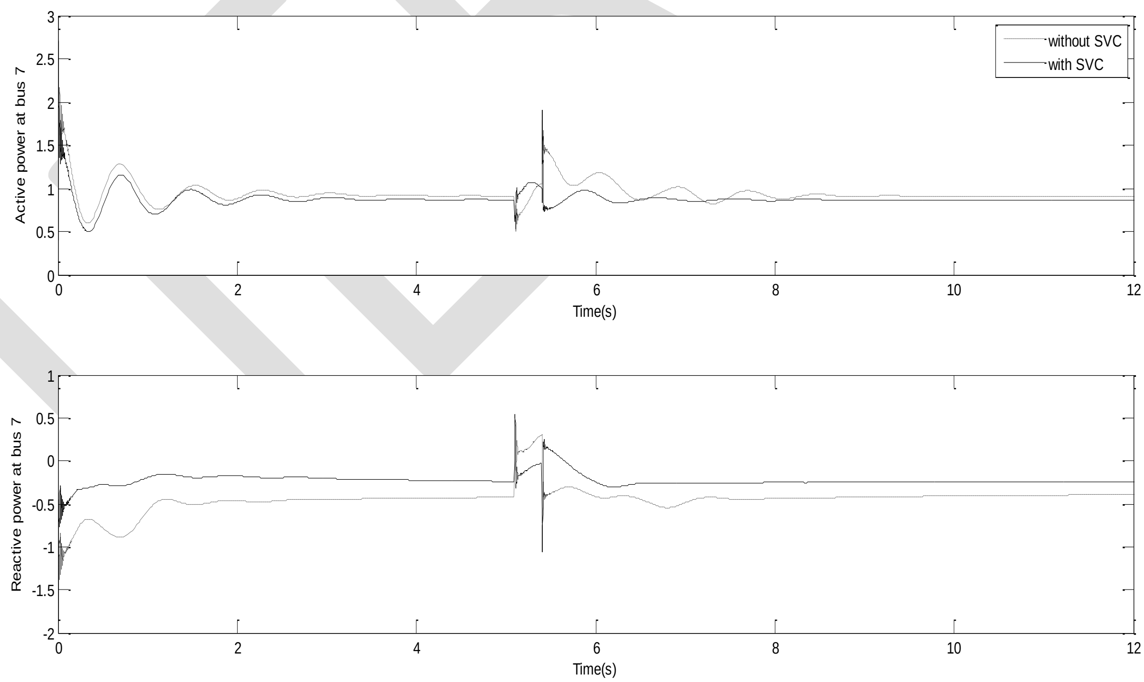

Figure6. Comparison of output waveforms of active power and reactive power at bus7 when fault occurs without SVC and with SVC

SIMULATION MODEL AND RESULTS WITH TCSC

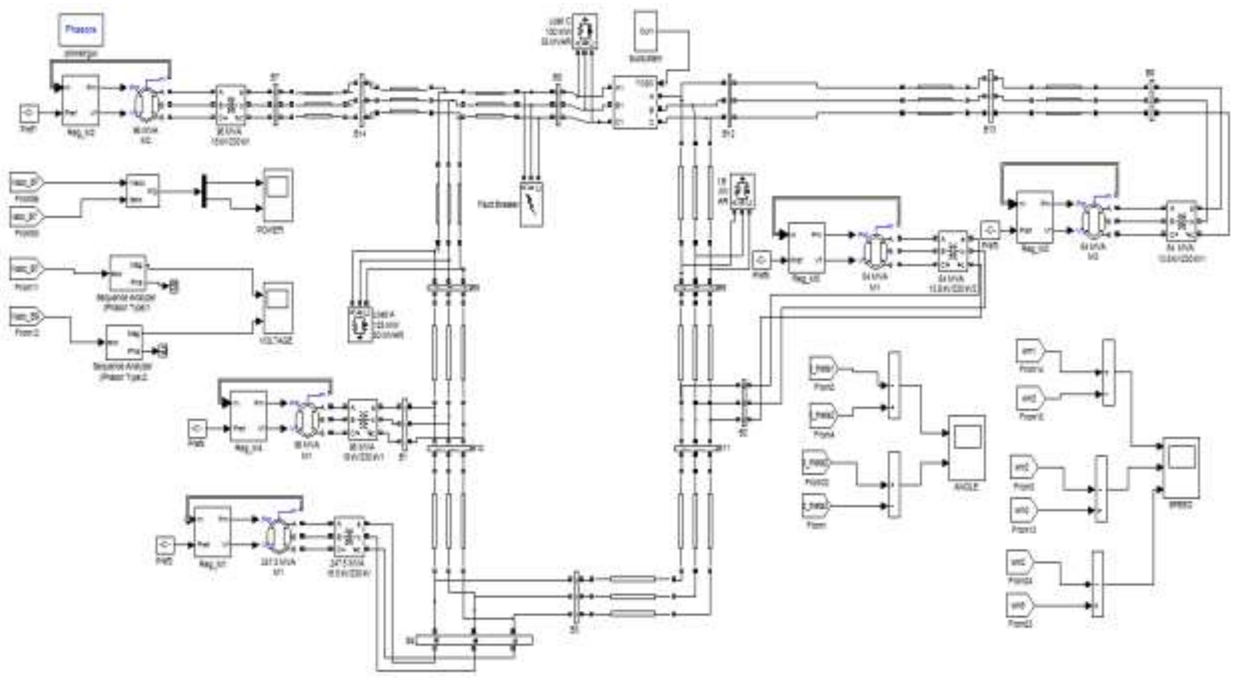

Figure7. Simulink model of a 14 bus system with five generating units and fault with TCSC

Output waveforms

The comparison of output waveforms without TCSC and with TCSC are observed as:

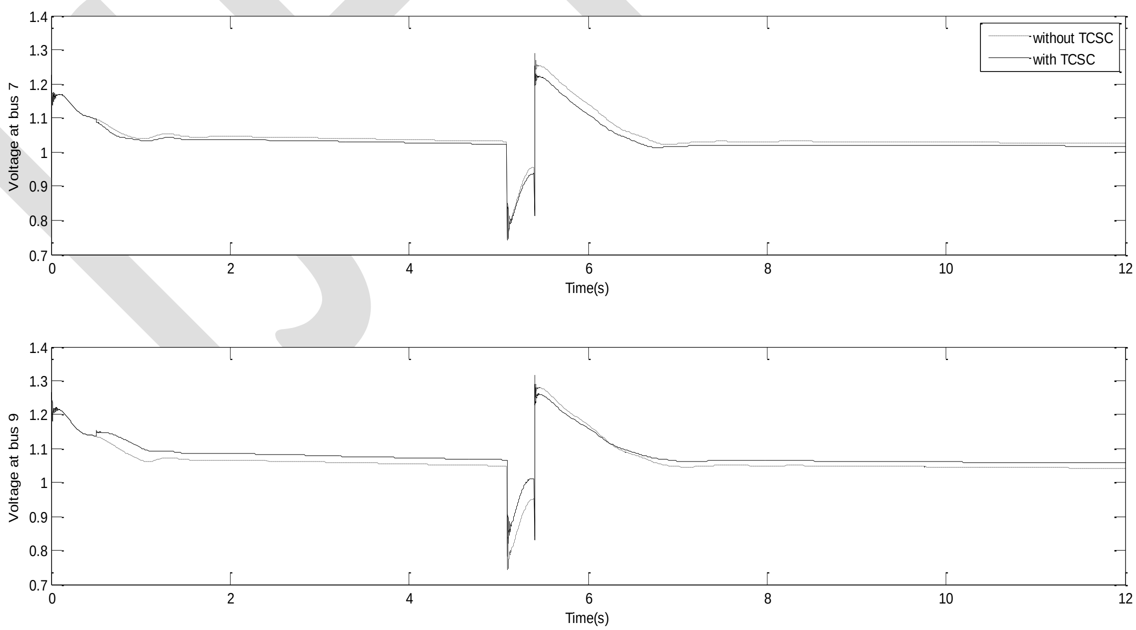

Figure8. Comparison of output waveforms of Voltages at bus 7 and bus 14 when fault occurs without TCSC and with TCSC

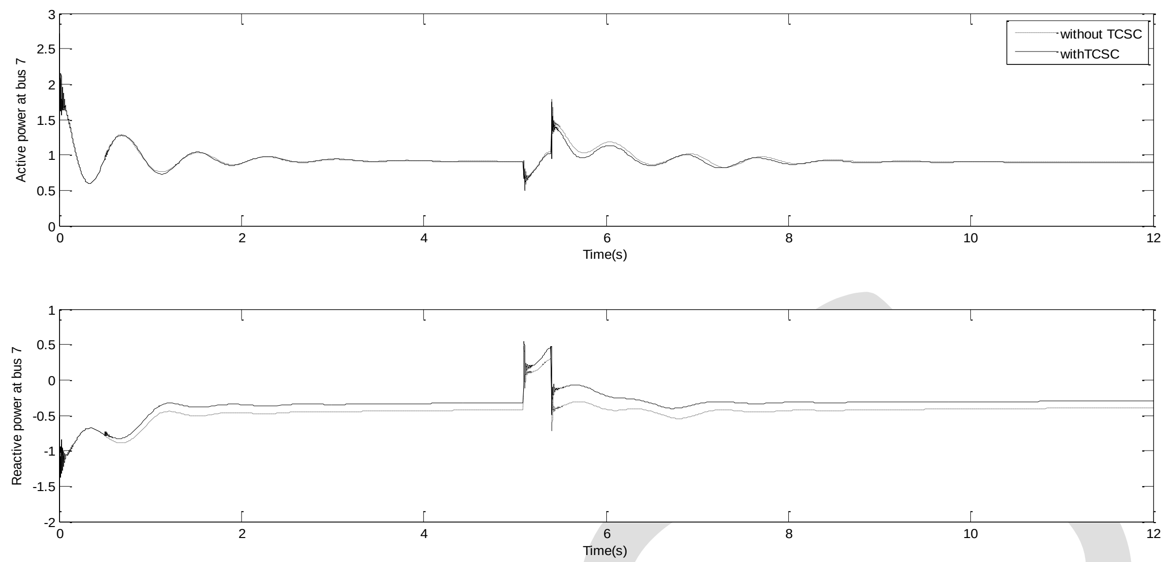

Figure9. Comparison of output waveforms of active power and reactive power at bus7 when fault occurs without TCSC and with TCSC

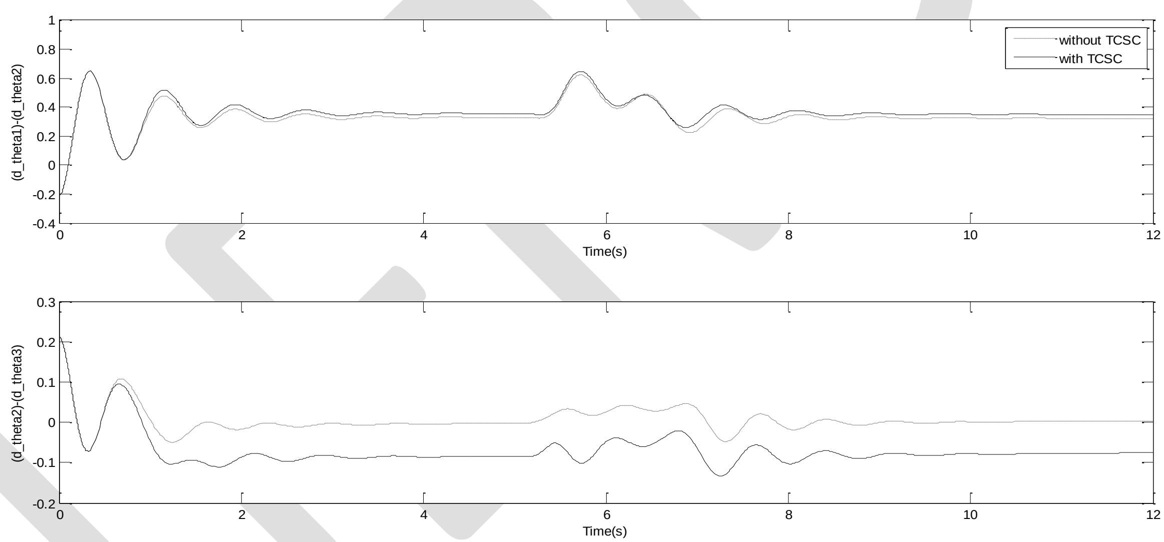

Figure10. Comparison of output waveforms of difference in rotor angle oscillations when fault occurs without TCSC and with TCSC

COMPARISON OF OUTPUT WAVEFORMS OF TCSC AND SVC

The output waveforms are compared for the devices SVC and TCSC. As TCSC is a series compensating Device it is best suited for increasing power transfer capability. While SVC on the other hand is a shunt compensating device and it is best suited for improving power system voltage. SVC also improves the transient stability effectively. It damps out the oscillations produced in voltage, active power, reactive power very fast. It also improves the rotor angle and speed synchronization and damp out the oscillations earlier [9][10].

International Journal of Engineering Research and General Science Volume 3, Issue 3, May-June, 2015
ISSN 2091-2730

Output waveforms

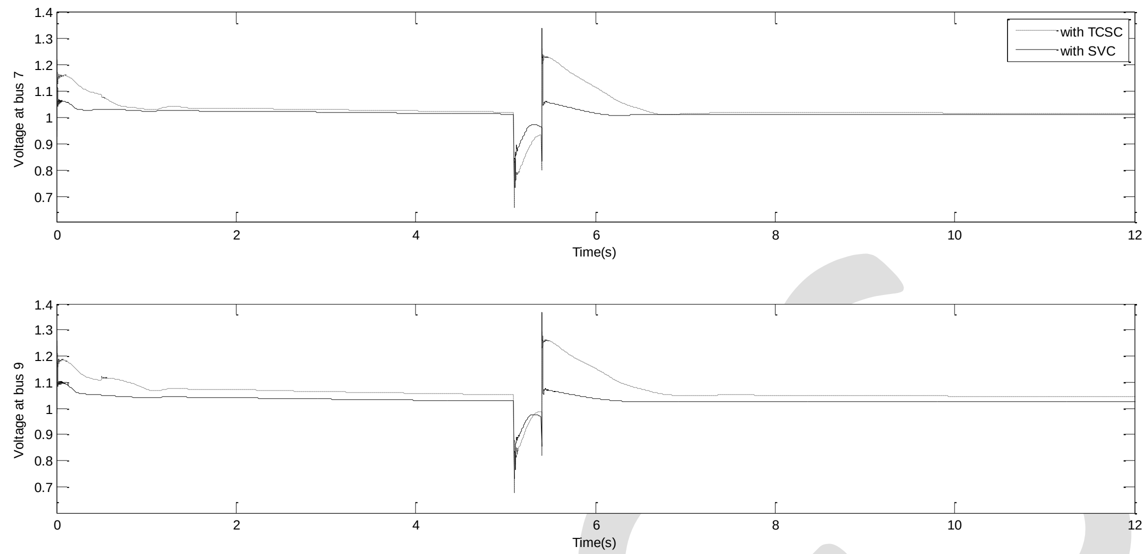

Figure11. Comparison of output waveforms of Voltages at bus 7 and bus 9 when fault occurs with SVC and with TCSC

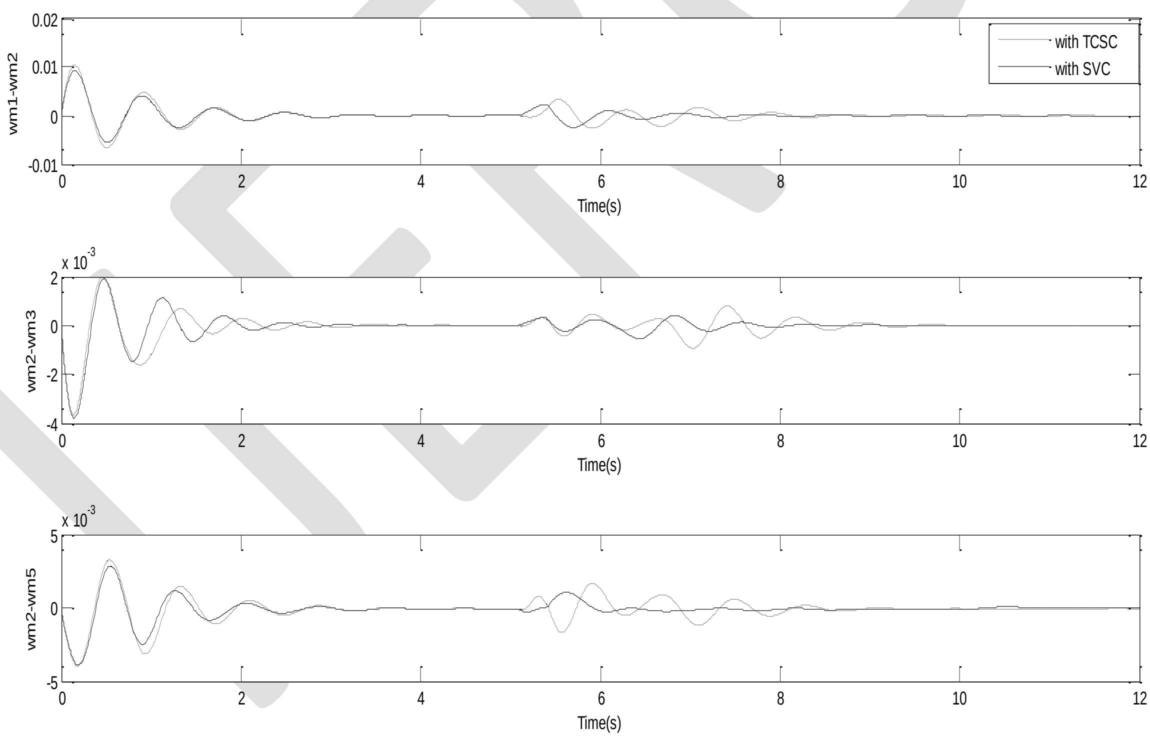

Figure12. Comparison of output waveforms of difference in rotor speed oscillations when fault occurs with SVC and with TCSC.

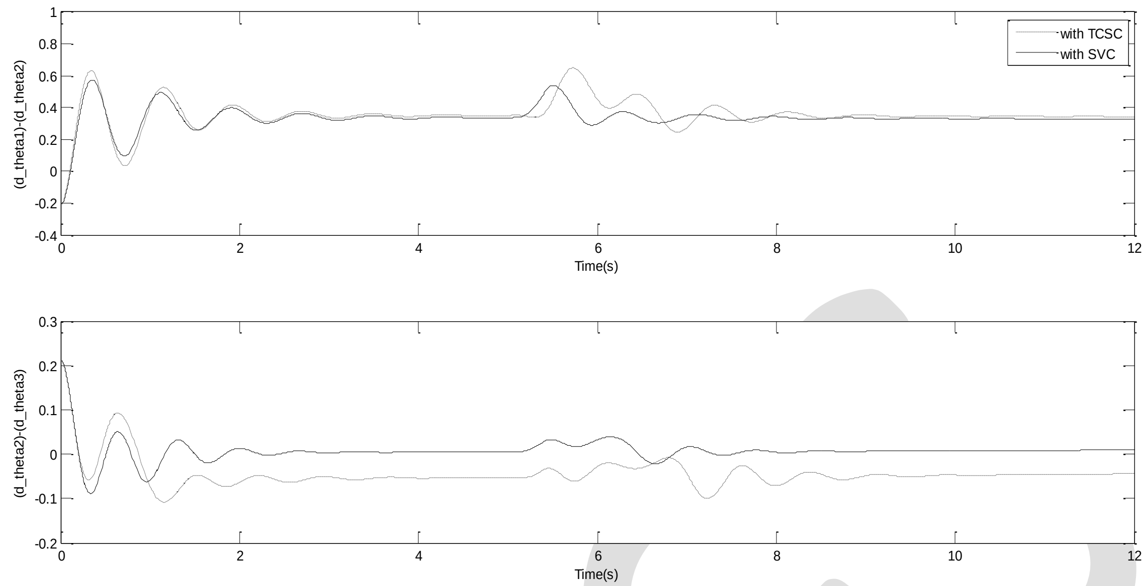

Figure13. Comparison of output waveforms of difference in rotor angle oscillations when fault occurs with SVC and with TCSC

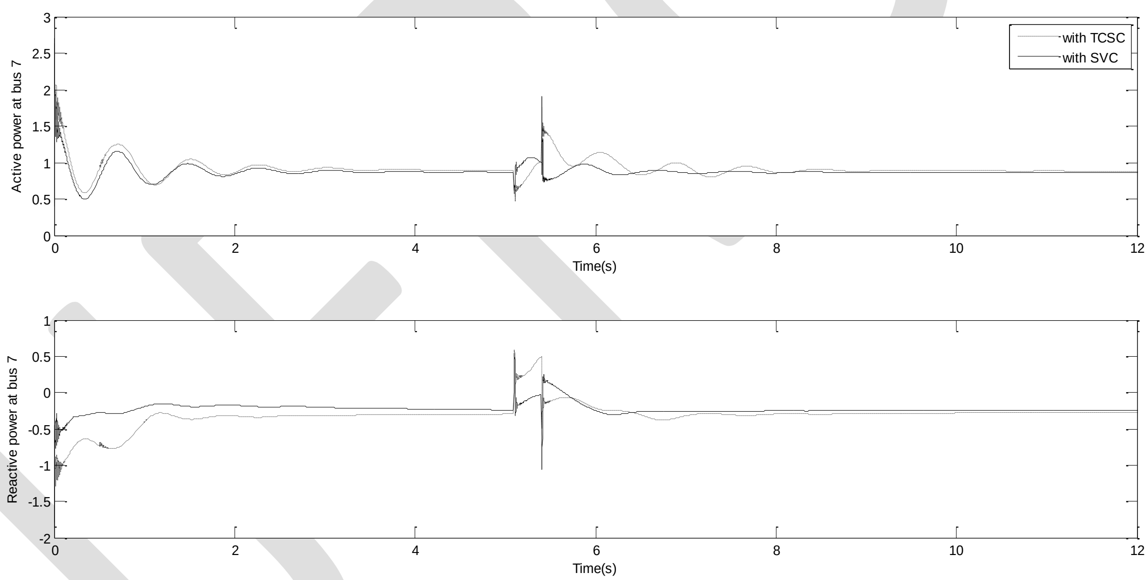

Figure14. Comparison of output waveforms of active power and reactive power at bus7 when fault occurs with SVC and with TCSC

CONCLUSION

This paper presented the simulation of two types of FACTS devices, TCSC and SVC to the 14 bus power system for the improvement of power system transient stability and overall stability of the power system. The output waveforms for voltage, active power, reactive power, rotor speed and angle oscillations are observed for device SVC, then all results are observed with device TCSC and after that all waveforms are compared for both the devices. Simulation is done in MATLAB/SIMULINK. Voltage profile is observed at bus7and 9. Active power and reactive power is observed at bus 7. The devices are connected at line between bus8 and bus12 and fault occurs on line between bus 8 and bus14. Fault occurs at 5.1 second to 5.4 second. It is observed that when the device SVC is used in the system it improves the voltage profile [6] and also damp out the oscillations in power, rotor speed and angle oscillations. It also injects the reactive power in the system. TCSC slightly improves the voltage profile and it is best suited for increasing power transfer capability. It is observed that out of TCSC and SVC, SVC damps out the oscillations faster than TCSC.

REFERENCES:

[1] Alok Kumar Mohanty and Amar Kumar Barik, "Power System Stability Improvement Using FACTS Devices", International Journal of Modern Engineering Research (IJMER), Vol.1, Issue.2, pp: 666-672, ISSN: 2249-6645.
[2] P. Kundur, "Power System Stability and Control", McGraw-Hill, Inc., 1994.
[3] Ranjit Kumar Bindal," A Review of Benefits of FACTS Devices in Power System", International Journal of Engineering and Advanced Technology (IJEAT), Volume-3, ISSN: 2249 – 895, Issue-4, April 2014, pp:105-108.
[4] N.G.Hingorani & L.Gyugyi, "Understanding FACTS concepts & technology flexible AC transmission system", Newyork: IEEE press 2000.
[5] Salma Keskes, Wissem Bahloul,M.B.A Kammown, "Transient stability enhancement of power system equipped with power system stabilizer by static var compensator", Fifth International renewable energy congress IREC,2014.
[6] M.Arun Bhaskar, C.Subramani, M.Jagdeesh kumar, Dr. S.S.Dash, "Voltage profile improvement using FACTS devices: A comparison between SVC, TCSC & TCPST", Intl. conf. on advances in recent technologies in communication and computing,2009.
[7] Amin Nasri, Mehrdad Ghandhari, Robert Eriksson, "Appropriate placement of series compensator to improve transient stability of power system", IEEE 2012.
[8] J.Gokula Krishnan, N.Senthil kumar, M.Abdullah khan, "On the optimal tuning of FACTS based stabilizers for dynamic stability of enhancement in multimachine power systems", IEEE 2011.
[9] Dr. N.Venkata Ramana & K.Chandrasekar, "Multi-objective: Genetic Algorithm to mitigate the composite problem of total transfer capacity,voltage stability & transmission loss minimization", IEEE 2007.
[10] K.Keerthivasan, V.Sharmila Deve , Jovitha Jerome and R.Ramanujam, "Modeling of SVC & TCSC for power system dynamic simulation", IEEE Seventh Intl. Conf. on power engineering,pp.696700,2005.
[11] Mohammadinia.M,Borzouie.M, "Optimal placement of FACTS device to improve transient stability of multi-machine power system" Transmission and distribution conference & exposition,2008 IEEE/PES, April 2008.
[12] Mr. Ketan G. Damor, "Improving Power System Transient Stability by using Facts Devices", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181,Vol. 3 Issue 7, July – 2014.
[13] Gannavarapu Akhilesh, "Power Flow Control/Limiting Short Circuit Current Using TCSC", ISSN 2222-1727 (Paper) ISSN 2222-2871(online), Vol. 3,No. 2, 2012.
[14] Kusum Arora, S.K. Agarwal, Narendra kumar and Dharam Vir," Simulation Aspects of Thyristor Controlled Series Compensator in Power System", IOSR Journal of Engineering 36(IOSRJEN), e-ISSN: 2250-3021, p-ISSN: 2278-8719, Vol. 3, Issue 4 (April. 2013), ||V1 || PP 17-26