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# TRASIENT STABILITY ENHANCEMENT OF TWO AREA SYSTEM USING FACTS CONTROLLER

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**Abstract:-**In this paper studies the comparative performance of UPFC(Unified Power Flow Controller) and SVC(Static Var Compensatar ) has been carried out for multi-machine power system to improve the transient stability power oscillation damping of power system using MATLAB7.6/Simulink. These devices have been applied to the transmission network using Power System blockset. The response of transmission systems has been studied for 3-phase symmetrical short-circuit fault with and without UPFC and SVC respectively, thus compare the impact of UPFC and SVC on the performance of power system on Transient Stability Enhancement .

**Keywords:**UPFC, SVC, MATLAB/Simulink, Transient stability, Multi-machine system.

## I.INTRODUCTION:

The FACTS is a concept based on power-electronic controllers, which enhance the value of transmission networks by increasing the use of their capacity. As these controllers operate very fast, they enlarge the safe operating limits of a transmission system without risking stability. FACTS controllers are capable of controlling the network condition in a very fast manner and this feature of FACTS can be exploited to improve the voltage stability, and steady state and transient stabilities of a complex power system [1-6]. This allows increased utilization of existing network closer to its thermal loading capacity, and thus avoiding the need to construct new transmission lines. Among the available FACTS devices, the Unified Power Flow Controller (UPFC) is the most versatile one that can be used to improve steady state stability, dynamic stability and transient stability [9].

In this paper investigates the improvement of transient stability of a two-area power system with a UPFC. A Matlab/Simulink model is developed for a two-area power system with a UPFC. The performance of UPFC is compared with SVC. From the simulation results, it is inferred that UPFC is an effective FACTS device for transient stability improvement. SVCs have been used for high performance steady state and transient voltage control compared with classical shunt compensation. SVCs are also used to dampen power swings, improve transient stability, and reduce system losses by optimized reactive power control [7-8].

## 2. UPFC CONTROLLER DESIGN

To operate the UPFC in the automatic control mode discussed in the third chapter, and also to use the UPFC to enhance power system stability and damp low frequency oscillations, two control designs need to be performed. A primary control design, referred to as the UPFC basic control design, involves simultaneous control of (i) real and reactive power flow on the transmission line, (ii) sending bus voltage magnitude, and (iii) DC voltage magnitude. A secondary control design, referred to as the damping controller design, is a supplementary control loop that is designed to improve transient stability of the entire electric power system [11-12].

## 3. STATIC VAR COMPENSATOR

The Static VAr Compensator (SVC) is a shunt connected device whose main functionality is to regulate the voltage at a chosen bus by suitable control of its equivalent reactance. A basic topology consists of a series capacitor bank, C, in parallel with a thyristor-controlled reactor, L, as shown in Figure 1. In practice the SVC can be seen as an adjustable reactance [10] that can perform both inductive and capacitive compensation. The SVC PI control scheme show in Figure 2. The details about the modelling of the SVC can be found in [10-13].

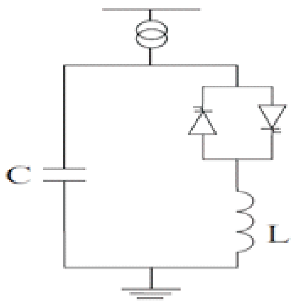



Figure 1 Basic SVC topology

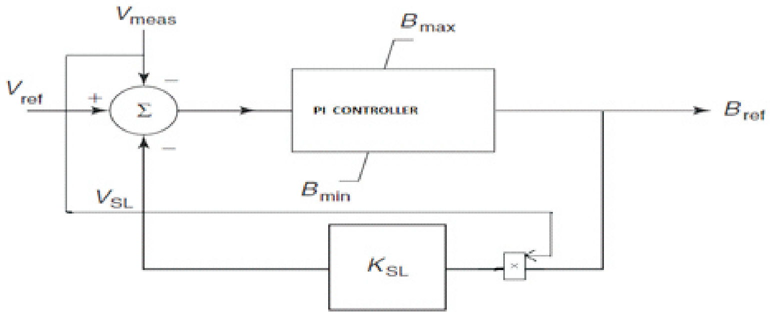
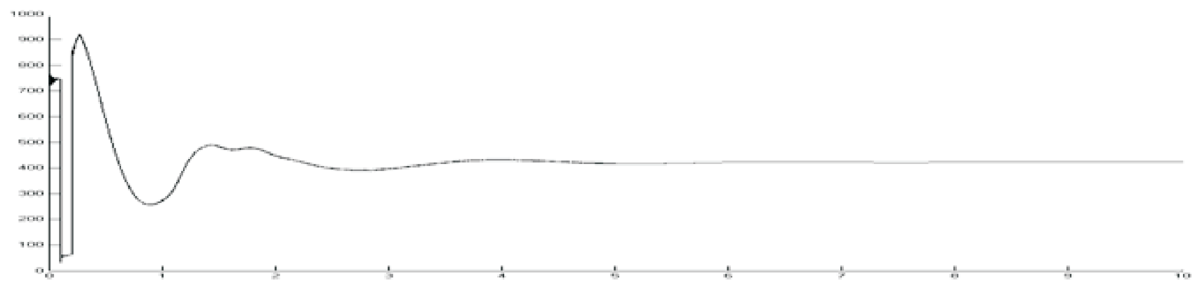



Figure 2 SVC PI control scheme

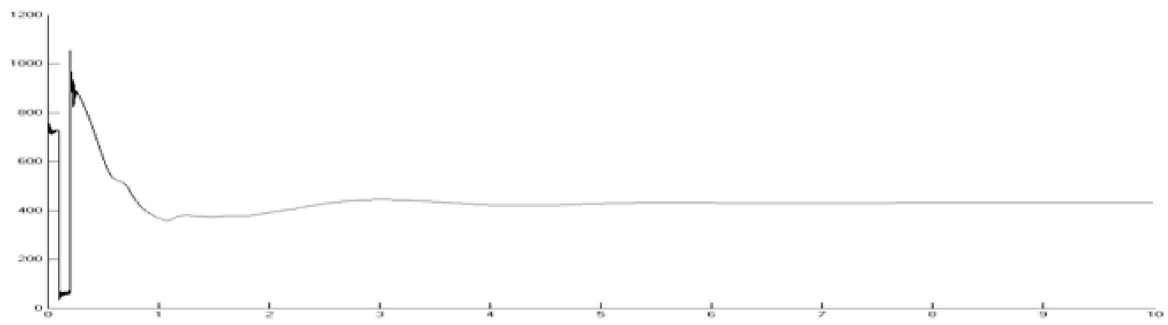
**4. SIMULATION AND TRANSIENT RESULTS ANALYSIS**

**4.1 TRANSIENT SIMULATION RESULTS**

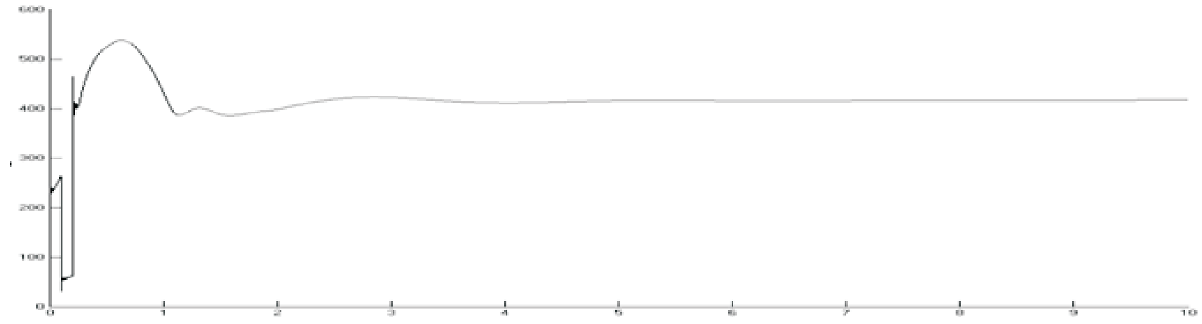
**4.1.1 Active power flow without, with UPFC and with SVC controller**



**Time in second**
**Figure3. Line power flow without FACTS controller**



**Time in second**
**Figure4. Line power flow with UPFC controller**

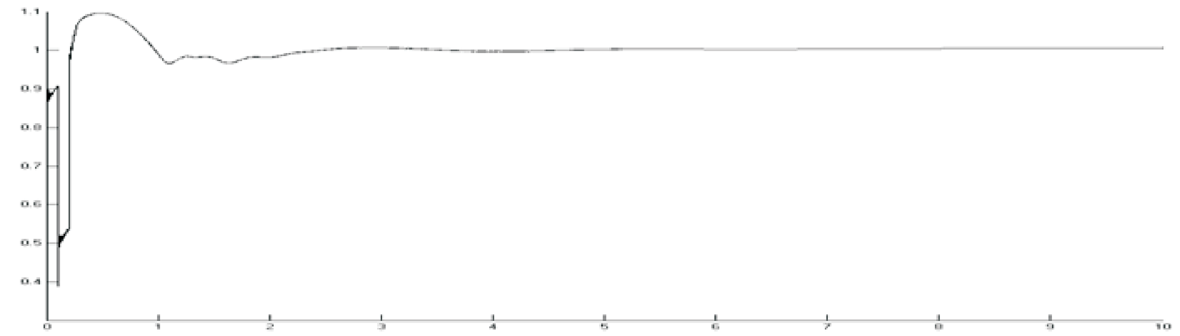



**Time in second**
**Figure6. Line power flow with SVC controller**

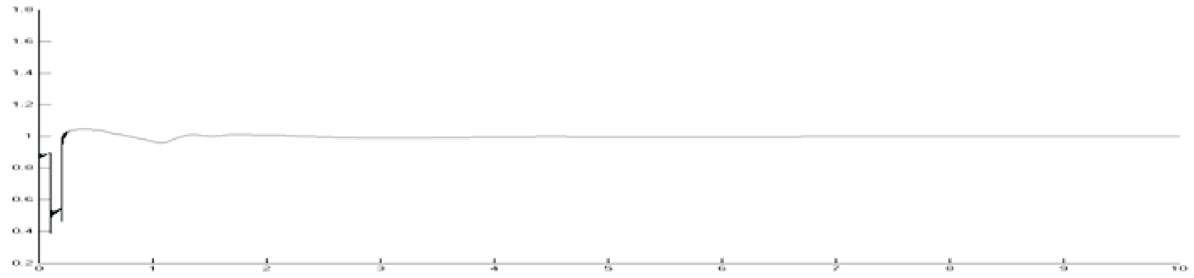
Figure3 shows simulation results for active power flow from area1 to area2 without FACTS controller .Three phase symmetric fault of 100 milliseconds is applied at time 0.1 second. After the occurrence of fault the power curve show oscillations which are settled to steady state in time span of 6seconds due to natural damping provide by the system. Hence the settling time is 6seconds. The first peak after the fault is observed at 0.5second.

Figure5 and Figure6 shows, that UPFC settling time is reduced to 3 second and the SVC settling time reduced to 4 second.

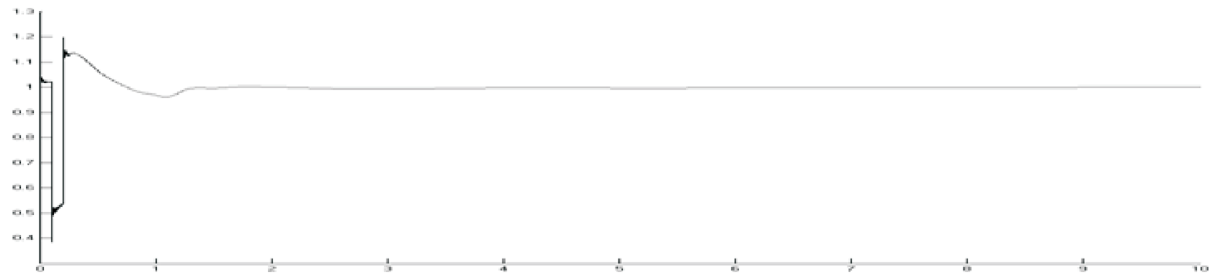
### 4.1.2 Terminal voltage of area1 without, with UPFC and with SVC controller




**Time in second**
**Figure7. Terminal voltage of area1 without FACTS controller**




**Time in second**
**Figure8. Terminal voltage of area1 with UPFC controller**



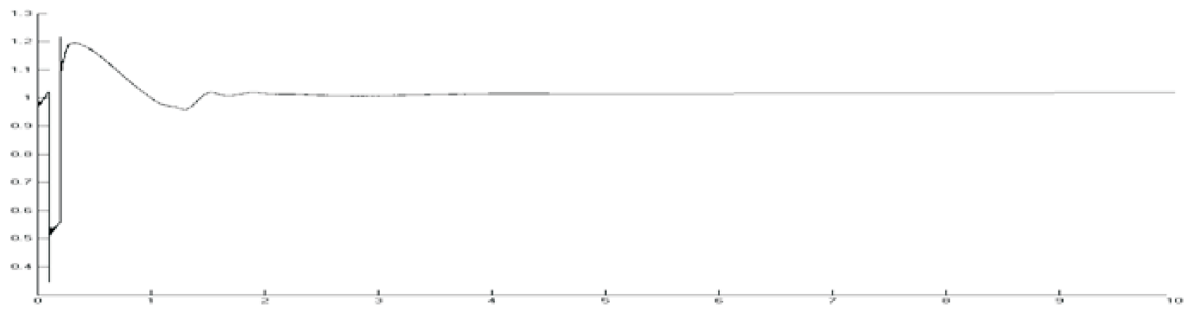
**Time in second**

**Figure9. Terminal voltage of area1 with SVC controller**

Figure7 shows simulation results for terminal voltage of area1 without FACTS controller .Three phase symmetric fault of 100 milliseconds is applied at time 0.1 second. After the occurrence of fault the power curve show oscillations which are settled to steady state in time span of 4seconds due to natural damping provide by the system. Hence the settling time is 4seconds. The first peak after the fault is observed at 0.5second.

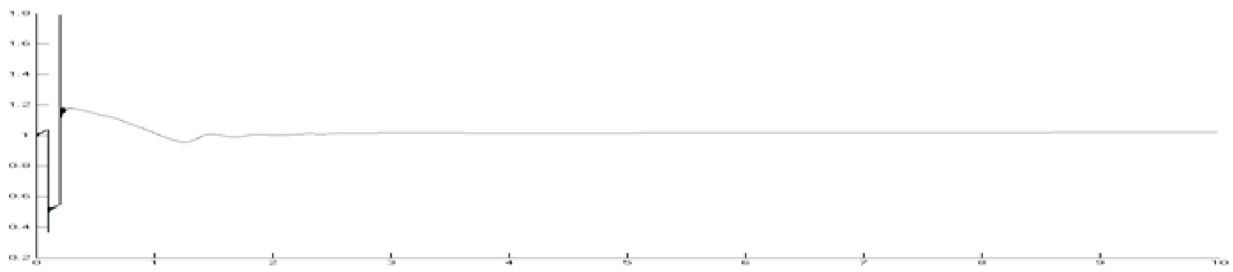
After the occurrence of fault the power curve show oscillations which are settled to steady state in time span of 1.5seconds due to damping provide by UPFC. Here the settling time is reduced to 1.5seconds. The first peak after the fault is observed at 0.25second. In SVC settling time is reduced to 2seconds and fault is observed at 0.4second.

### 4.1.3 Terminal voltage of area2 without, with UPFC and with SVC controller



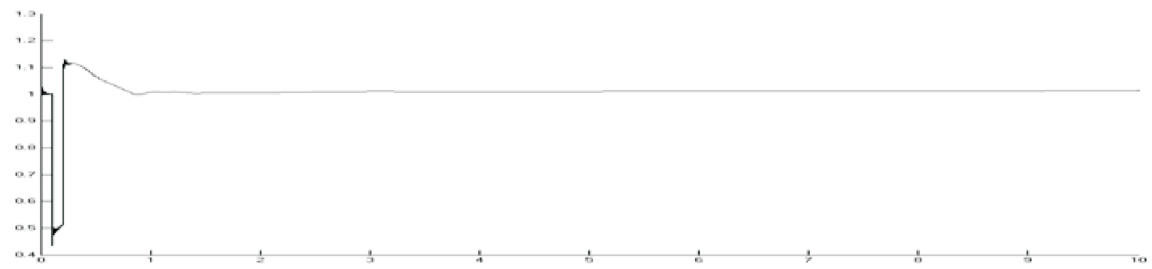
**Time in second**

**Figure10. Terminal voltage of area2 without FACTS controller**



**Time in second**

**Figure11. Terminal voltage of area2 with UPFC controller**

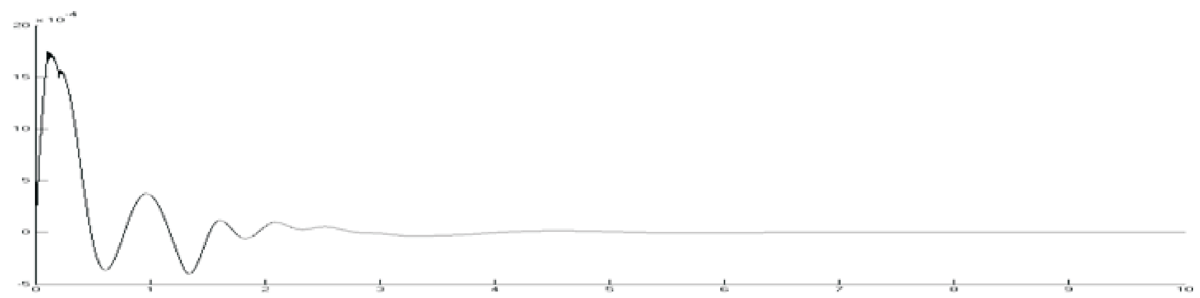


**Time in second**
**Figure12 Terminal voltage of area2 with SVC controller**

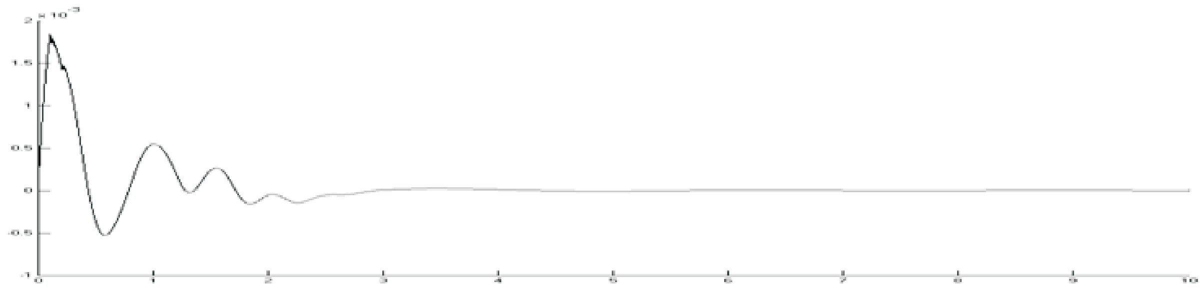
Figure10 shows simulation results for terminal voltage of area2 without FACTS controller .Three phase symmetric fault of 100 milliseconds is applied at time 0.1 second. After the occurrence of fault the power curve show oscillations which are settled to steady state in time span of 3seconds due to natural damping provide by the system. Hence the settling time is 3seconds. The first peak after the fault is observed at 0.5second.

Figure11 and Figure12 shows, that UPFC reduced settling time to 1.7 second and SVC settling time is reduced 1.8 second.

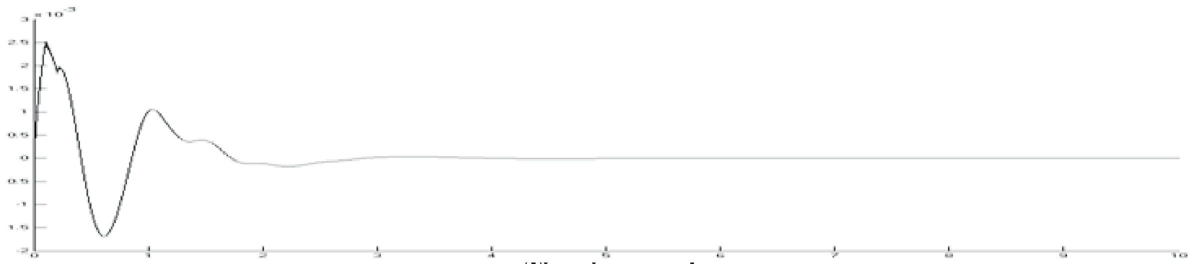
**4.1.4 Local mode of oscillations for ω3-ω4 without, with UPFC and with SVC controller**



**Time in second**
**Figure13. Local mode of speed oscillation for ω3-ω4 without FACTS controller**



**Time in second**
**Figure14. Local mode of speed oscillation for ω3-ω4 with UPFC controller**



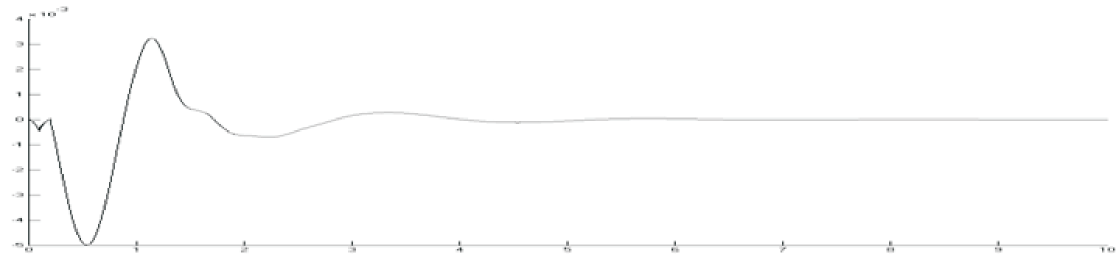
Time in second

**Figure15. Local mode of speed oscillation for ω3-ω4 with SVC controller**

Figure13 shows local mode speed oscillations for ω3-ω4 without FACTS controller. Three phase symmetric fault of 100 milliseconds is applied at time 0.1 second. From the result the oscillations in generator speed of area2 (generator3 and generator4) increase and settling time is 5second.

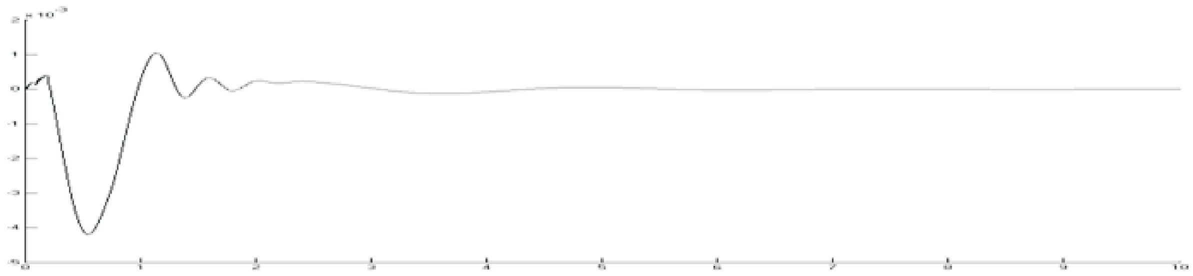
The oscillations in generator speed of area2 (generator3 and generator4) decrease and settling time is reduced to 3second with UPFC and 4 second with SVC. The transient stability of multi-machine power system is improved with both of UPFC and SVC.

**4.1.5 Inter-area mode of speed oscillations for ω1-ω4 without, with UPFC and with SVC controller**



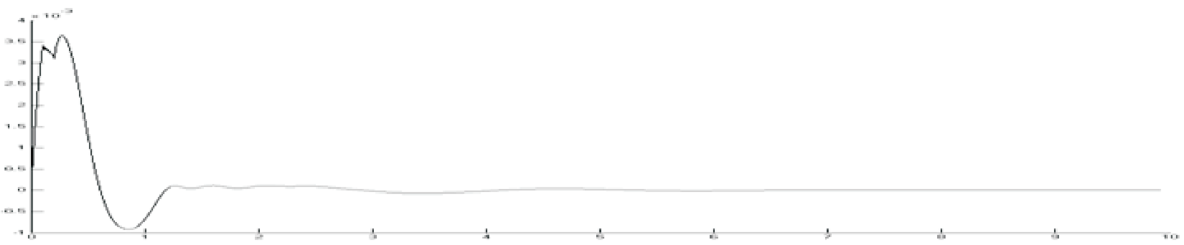
Time in second

**Figure16. Inter-area mode of speed oscillation for ω1-ω4 without FACTS controller**



Time in second

**Figure17. Inter-area mode of speed oscillation for ω1-ω4 with UPFC controller**



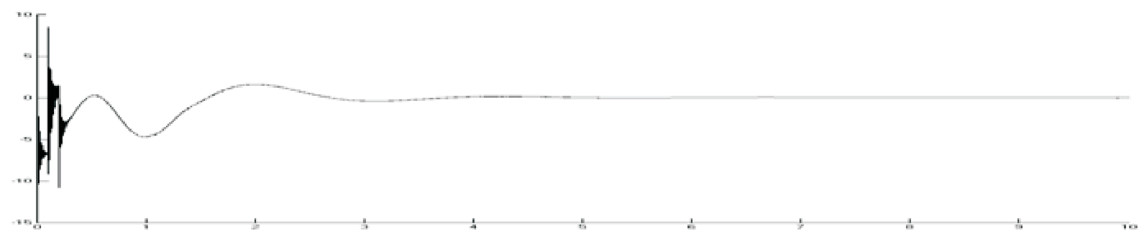
Time in second

**Figure18. Inter-area mode of speed oscillation for ω1-ω4 with SVC controller**

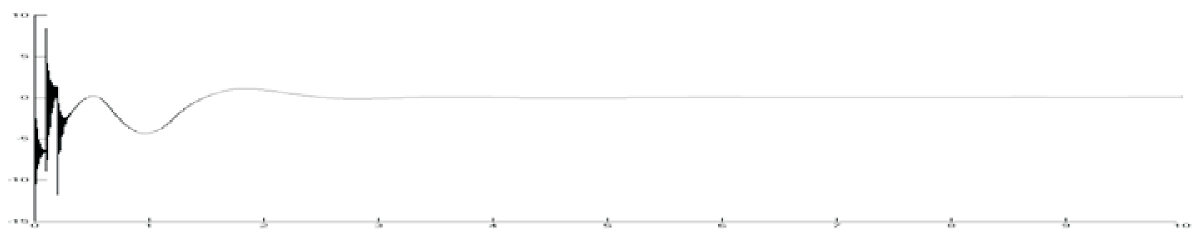
Figure16 shows inter-area mode of speed oscillations for ω1-ω4 without FACTS controller. Three phase symmetric fault of 100 milliseconds is applied at time 0.1 second. From the result the oscillations in generator speed of area1 and area2 (generator1 and generator4) increase and settling time is 5second.

The oscillations in generator speed of area1 and area2 (generator1 and generator4) decrease and settling time is reduced to 3second with UPFC, 4second with SVC. Hence the transient stability of multi-machine power system is improved with UPFC.

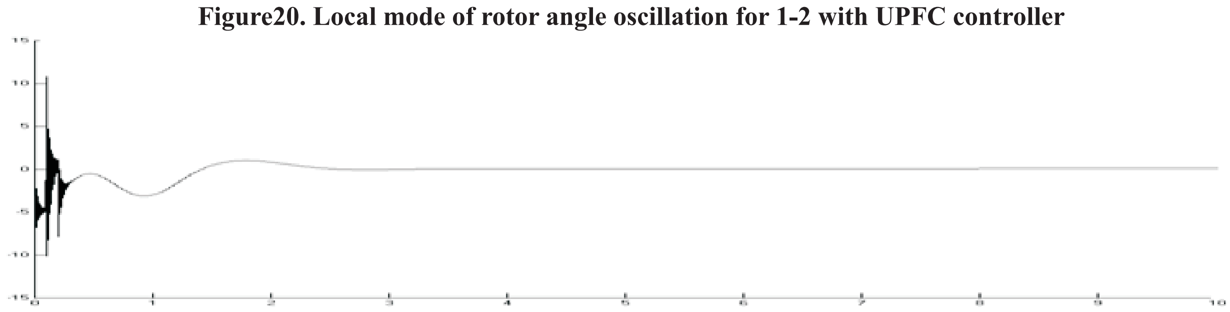
**4.1.6 Local mode of rotor angle oscillations for 1-2 without, with UPFC and with SVC controller**



**Time in second**
**Figure19. Local mode of rotor angle oscillations for 1-2 without FACTS controller**



**Time in second**
**Figure20. Local mode of rotor angle oscillation for 1-2 with UPFC controller**

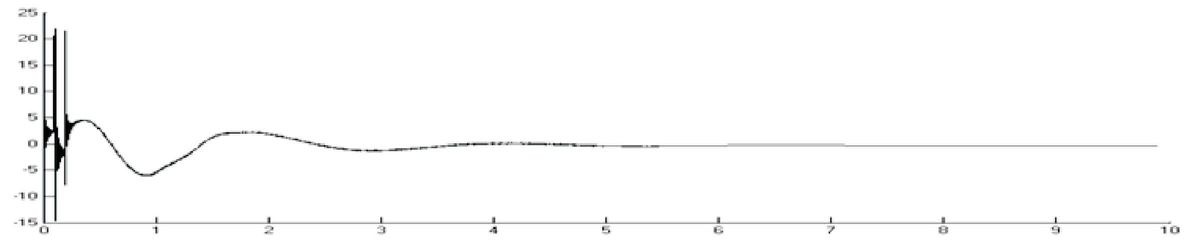


**Time in second**
**Figure21. Local mode of rotor angle oscillation for 1-2 with SVC controller**

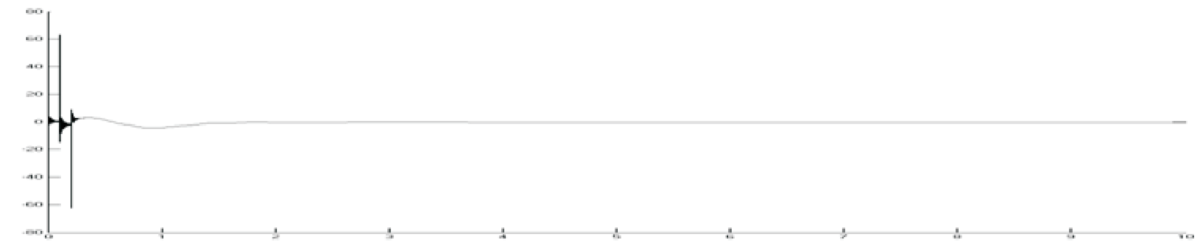
Figure19. shows local mode of rotor oscillations for 1-2 without FACTS controller. Three phase symmetric fault of 100 milliseconds is applied at time 0.1 second. From the result the oscillations in generator rotor angle of area1 (generator1 and generator2) increase and settling time is 4second.

The oscillations in generator rotor angle of area1 (generator1 and generator4) decrease and settling time is reduced to 2.5second with FACT Device. Hence the transient stability of multi-machine power system is improved.

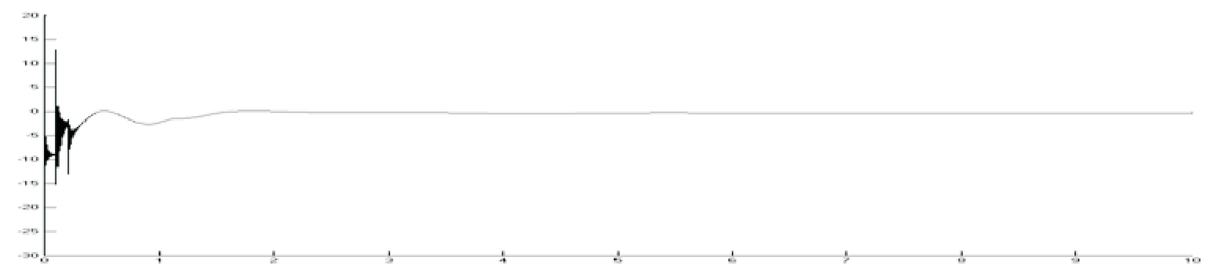
**4.1.7 Inter-area mode of rotor angle oscillations for 1-4 without, with UPFC and with SVC controller**




**Time in second**
**Figure22. Inter-area mode of rotor angle oscillations for 1-4 without FACTS controller**




**Time in second**
**Figure23.Inter-area mode of rotor angle oscillation for 1-4 with UPFC controller**




**Time in second**
**Figure24.Inter-area mode of rotor angle oscillations for 1-4 with SVC controller**

Figure22. shows local mode of rotor angle oscillations for 1-4 without FACTS controller. Three phase symmetric fault of 100 milliseconds is applied at time 0.1 second. From the result it is seen that the oscillations in generator rotor angle of area1 and area2 (generator1 and generator4) increase and settling time is 4second.

The settling time is reduced to 1.5second with UPFC and 1.8second with SVC. The transient stability of multi-machine power system is improved.

## CONCLUSION

The power system stability improvement of a multi-machine power system by various FACTS devices such as SVC and UPFC is analysed. The effect of SVC and UPFC on power system stability of multi-machine power system is studied. The dynamics of the system is studied at the event of a major disturbance and three phase symmetric fault of 100ms and the results are discussed. Then the performance of the UPFC for power system stability improvement is compared with SVC. It is clear from the simulation results that there is a considerable improvement in the system performance with the presence of UPFC for which the settling time is reduced. The oscillations in local and inter-area mode is also reduced and hence the power system stability is improved.

## REFERENCE

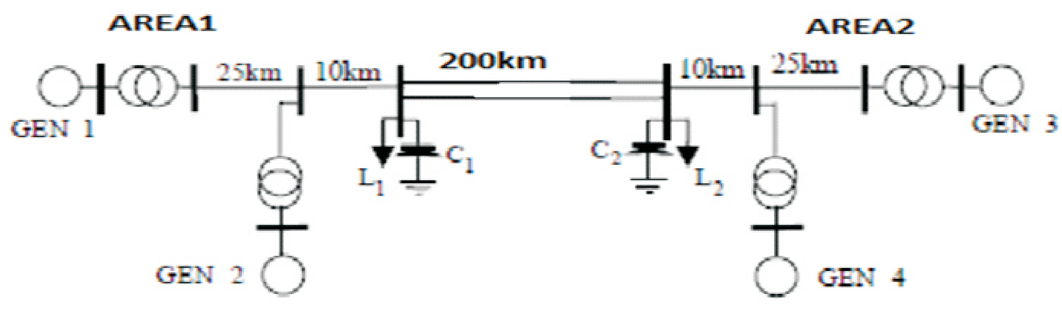
1.Igor Papic, Peter Zunko, 2002, "Mathematical Model and Steady State Operational Characteristics of a Unified Power Flow Controller,"Electro-technical Review, Slovenija, 69(5), pp. 285-290.
2.Prechanon Kumkratug, 2009, "Application of UPFC to Increase Transient Stability of Inter-Area Power System," Journal of Computers, 4(4), pp. 283-287.

3.Prechanon Kumkratug, Panthep Laohachai, 2007, "Direct Method of Transient Stability Assessment of a Power System with a SSSC," Journal of Computers, 2(8), pp. 77- 82.
4.S.V. Ravi Kumar, S. Siva Nagaraju, 2007, "Transient Stability Improvement using UPFC and SVC," ARPN Journal of Engineering and Applied Sciences, 2(3), pp. 38- 45.
5.Kazemi, F. Mahamnia, 2008, "Improving of Transient Stability of Power Systems by Supplementary Controllers of UPFC using Different Fault Conditions," WSEAS Transactions on Power Systems, 3(7), pp. 547-556.
6.S. Panda, Ramnarayan N. Patel, 2006, "Improving Power System Transient Stability with an off-centre Location of Shunt FACTS Devices," Journal of Electrical Engineering, 57(6), pp. 365-368.
7.N. Mithulananthan, C.A. Canizares, J. Reeve, Graham J. Rogers, 2003, "Comparison of PSS, SVC and STATCOM Controllers for Damping Power System Oscillations," IEEE Transactions on Power Systems, 18(2), pp. 786-792.
8.E.Z. Zhou, 1993, "Application of Static Var Compensators to Increase Power System damping," IEEE Transactions on Power Systems, 8(2), pp. 655-661.
9.M. Noroozian, L. Angquist, M. Ghandhari, G. Andersson, 1997, "Use of UPFC for Optimal Power Flow Control," IEEE Transactions on Power Delivery, 12(4), pp. 1629- 1634.
10.Higorani, N.G, Gyugyi. L., Understanding FACTS Devices, IEEE Press 2000
11.Huang, Z., Ni, Y., Shen, C.M., Wu, F.F., Chen, S., Zhang, B., 'Application of Unified Power Flow Controller in Interconnected Power Systems -- Modelling, Interface, Control Strategy and Case Study', IEEE Power Engineering Society Summer Meeting, 1999
12.Uzunovic, E., Canizares, C.A., Reeve, J., 'EMTP Studies of UPFC Power Oscillation Damping', Proceedings of the North American Power Symposium (NAPS), San Luis Obispo, CA, October 1999, pp. 405-410
13.Y.H. Song and A.T. Johns. Flexible AC Transmission Systems. IEE Power and energy series, UK, 1999.

**APPENDIX**

The system consists of two similar areas connected by a weak tie. Each area consists of two coupled units, each having a rating of 900 MVA and 20kV. The generator parameters in per unit on the rated MVA and kV base are:

| | | | | |
|---|---|---|---|---|
| $X_d = 1.305$ | $X'_d = 0.296$ | $X''_d = 0.252$ | $X_q = 0.474$ | $X''_q = 0.243$ |
| $X_1 = 0.18$ | $T'_d = 0.01$ | $T''_d = 0.53$ | $T''_q = 0.1$ | H=6.5( for GEN1 to GEN4) |



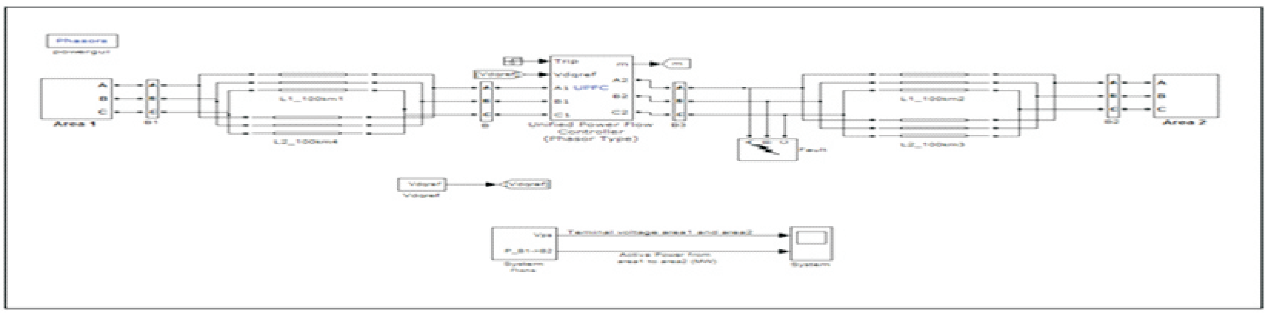

The transmission system nominal voltage is 230kV. the parameters of the lines in per unit on 100MVA, 230kV base are:
R=0.0001 pu/km xl= 0.001 pu/km bc= 0.00175 pu/km

The system is operating with area 1 exporting 400MW to area 2, and the generating units are loaded as follows:

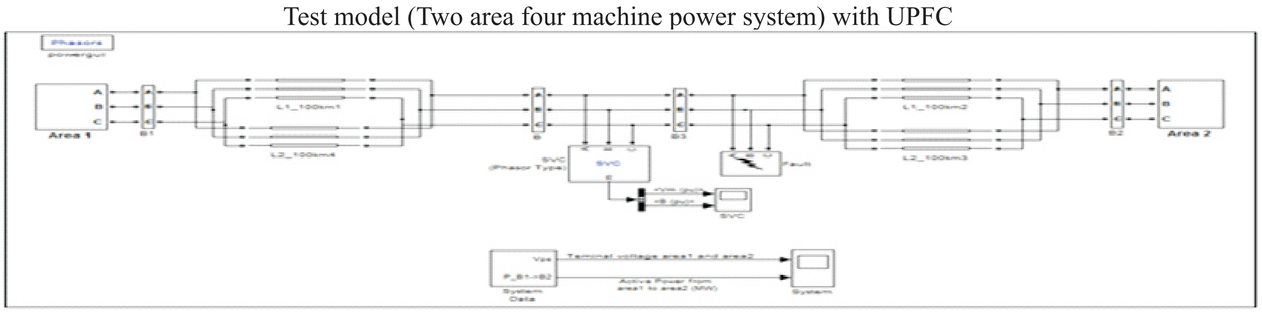
GEN1: P = 700MW Q = 185 MVAr Et = 1.03 ∟20.20
GEN2: P = 700MW Q = 235 MVAr Et = 1.01 ∟10.50
GEN3: P = 719MW Q = 176 MVAr Et = 1.03∟ - 6 . 8 0
GEN4: P = 700MW Q = 202 MVAr Et = 1.03∟ - 1 7 . 0 0

The loads and reactive power supplied

A: PL = 967 MW QL = 100MVAr QC = 187MVAr
B: PL= 1767 MW QL = 100MVAr Qc = 187 MVAr




Test model (Two area four machine power system) with UPFC




Test model (Two area four machine power system) with SVC