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Comparison of FACTS Devices for Power System Transient Stability Improvement

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ABSTRACT

Recent development of power electronics introduces the use of FACTS devices in power systems. FACTS devices are capable of controlling the network condition in a very fast manner by reactive power management and this unique feature of FACTS devices can be exploited to improve the transient stability of a system. Transient stability control plays a significant role in ensuring the stable operation of power systems in the event of large disturbances and faults. The improvement of transient stability of a two-area power system, using UPFC (Unified Power Flow Controller) which is an effective FACTS (Flexible AC Transmission System) device capable of controlling the active and reactive power flows in a transmission line by controlling appropriately its series and shunt parameters, also combined with Distributed Generation (DG) connected in the DC link to mitigate power quality disturbances. A collection of measured performance characteristics is presented to illustrate the unique capabilities of UPFC. The performance of UPFC is compared with other FACTS devices such as Static Synchronous Series Compensator (SSSC), Thyristor Controlled Series Capacitor (TCSC), and Static VAR Compensator (SVC) respectively.

Keywords : SVC, STATCOM, SSSC, Transient Stability, UPFC.

I. INTRODUCTION

Modern power system is a complex network comprising of numerous generators, transmission lines, variety of loads and transformers. As a consequence of increasing power demand, some transmission lines are more loaded than the planned capacity when they were built. With the increased loading of long transmission lines, the problem of transient stability after a major fault can become a transmission limiting factor. Now power engineers are much more concerned about transient stability problem due to blackout in North East United States, Scandinavia, England and Italy [1]. Transient stability refers to the capability of a system to maintain synchronous operation in the event of large disturbances such as multi-phase short-circuit faults or switching of lines. The resulting system response involves large excursions of generator rotor angles and is influenced by the nonlinear power angle relationship. Stability depends upon both the initial operating conditions of the system and the severity of the disturbance. Recent development of power electronics introduces the use of flexible ac transmission system (FACTS) controllers in power systems. 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. This allows increased utilization of existing network closer to its thermal loading capacity and thus avoiding the need to construct new transmission lines. Static VAR Compensator (SVC) is a first generation FACTS device that can control voltage at the required bus thereby improving the voltage profile of the system. The primary task of an SVC is to maintain the voltage at a particular bus means of reactive power compensation (obtained by varying the firing angle of the thyristors). 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 [2].

Thyristor Controlled Series Capacitor (TCSC) is one of the important members of FACTS family that is increasingly applied with long transmission lines by the utilities in modern power systems. It can have various roles in the operation and control of power systems, such as scheduling power flow, decreasing unsymmetrical components, reducing net loss, providing voltage support, limiting short-circuit currents, mitigating sub synchronous resonance (SSR),damping the power oscillation, and enhancing transient stability [2].

A Static Synchronous Series Compensator (SSSC) is a member of FACTS family which is connected in series with a power system. It consists of a solid state voltage source converter which generates a controllable alternating current, voltage at fundamental frequency. When the injected voltage is kept in quadrature with the line current, it can emulate as inductive or capacitive reactance so as to influence the power flow through the transmission line. While the primary purpose of a SSSC is to control power flow in steady state, it can also improve transient stability of a power system [2].

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. The UPFC can independently control many parameters since it is the combination of Static Synchronous Compensator (STATCOM) and SSSC. These devices offer an alternative mean to mitigate power system oscillations. UPFC can improve stability of single machine infinite bus (SMIB) system and multi machine system. The inter-area power system has special characteristic of stability behaviour. The improvement of transient stability of a two-area power system with a UPFC is investigated. A Matlab/Simulink model can be developed for a two-area power system with a UPFC. The performance of UPFC can be compared with other FACTS devices such as SVC, TCSC, and SSSC respectively.

The power transfer capability of long transmission lines is usually limited by large signal stability. Economic factors, such as the high cost of long lines and revenue from the delivery of additional power, give strong incentives to explore all economically and technically feasible means of raising the stability limit. On the other hand, the development of effective ways to use transmission systems at their maximum thermal capability has caught much research attention in recent years. The unified power-flow controller (UPFC) is a member of the FACTS family with very attractive features. This device can independently control many parameters, so it is the combination of the properties of a Static synchronous compensator (STATCOM) and static synchronous series compensator (SSSC).An approach to solve first-swing stability problem using UPFC, along with a comprehensive analysis. The advantages of this control strategy are firstly, using the local variable of system and secondly, offer better stability performances in comparison with the other existing methods. By modulating the active and reactive powers, it is possible to bring a vast improvement in the first swing transient stability.

II. FACTS DEVICES

Transmission lines in congested areas are often driven close to or even beyond their limits in order to satisfy the increased electric power consumption and trades. Thus, secure operation and reliable supply is endangered by the higher risks for faulted lines. But the construction of additional power lines is often difficult for environmental, economical and political reasons. This is where the technology of FACTS provides a significant opportunity.

Changing the voltage at a certain bus or the power flow on a line also modifies the power flow in the surrounding grid. If a FACTS device is placed in the vicinity of another, mutual influences may arise which could be the positive impacts of a single device. Coordination is needed to determine the variables such that detrimental actions are prevented. Additionally, measures in other parts of the grid have to be taken into account such that it is avoided that distant lines become overloaded or that voltages at other buses are driven to unacceptable values.

The resulting objective function includes several components such as minimizing active power losses, avoiding overloaded lines and keeping bus voltages within an acceptable range and close to their reference values. A specific type of FACTS device is able to influence a certain parameter in the grid which is related to a particular part of the objective function. For instance, the SVC injects or absorbs reactive power which is strongly coupled to the voltage.

A. Identification of FACTS Projects

- To conduct a detailed network study & investigate the critical conditions of a grids connections. These conditions could include risks of voltage problems or even voltage collapse, undesired power flows, as well as the potential for power swings or sub synchronous resonances.
- For a stable grid, the optimized utilization of the transmission lines e.g. increasing the energy transfer capability could be investigated.
- If there is a potential for improving the transmission system, either through enhanced stability or energy transfer capability, the appropriate FACTS device and its required rating can be determined.
- Based on the technical information, an economical study can be performed to compare type of FACTS devices or conventional solutions with the achievable benefits.

B. Two Area Power System Model

Consider a two area power system (Area-1 & Area-2) with series and shunt FACTS devices, connected by a single circuit long transmission line as shown in Fig.1 and Fig.2 respectively.

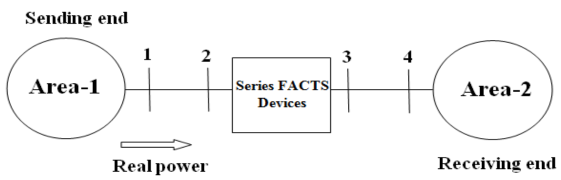


Fig 1. Two-area power system with series FACTS device

Here, the series FACTS devices such as UPFC (combination of STATCOM and SSSC), SSSC, and TCSC are equipped between bus-2 and bus-3. The direction of real power flow is from Area-1 to Area-2. In the two-area power system model, the Area-1 consists of Generator 1 (G1) and Generator 2 (G2) and the Area-2 consist of the shunt FACTS device such as SVC is equipped at bus-2. The direction of real power flow is from Area-1 to Area-2. In the two-area power system model, the Area-1 consists of Generator 1 (G1) and Generator 2 (G2) and the Area-2 consists of Generator 3 (G3) and Generator (G4).

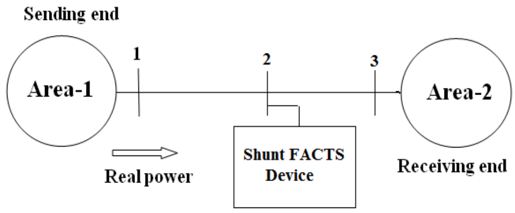


Fig 2. Two-area power system with shunt FACTS device

Two area power systems can be used for the problem identification in different FACTS devices. Also compare Shunt & Series, UPFC device.

III. UPFC

A unified power flow controller (UPFC) is the most promising device in the FACTS concept. It has the ability to adjust the three control parameters, i.e. the bus voltage, transmission line reactance, and phase angle between two buses, either simultaneously or independently. A UPFC performs this through the control of the in-phase voltage, quadrature voltage, and shunt compensation. The basic components of the UPFC are two voltage source inverters (VSIs) sharing a common dc storage capacitor, and connected to the power system through coupling transformers. One VSI is connected in shunt to the transmission system via a shunt transformer, while the other one is connected in series through a series transformer. A basic UPFC functional scheme is shown in Fig3.

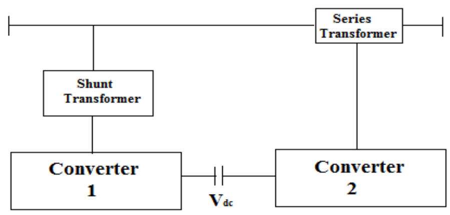


Fig 3. Basic functional scheme of UPFC.

For the maximum effectiveness of the controllers, the selection of installing locations and feedback signals of FACTS based stabilizers must be investigated. On the other hand, the robustness of the stabilizers to the variations of power system operating conditions is equally important factor to be considered. Also, the coordination among different stabilizers is a vital issue to avoid the adverse effects. Additionally, performance comparison is an important factor that helps in selection of a specific FACTS device. The effect of UPFC is more pronounced when the controller is placed near heavily disturbed generator.

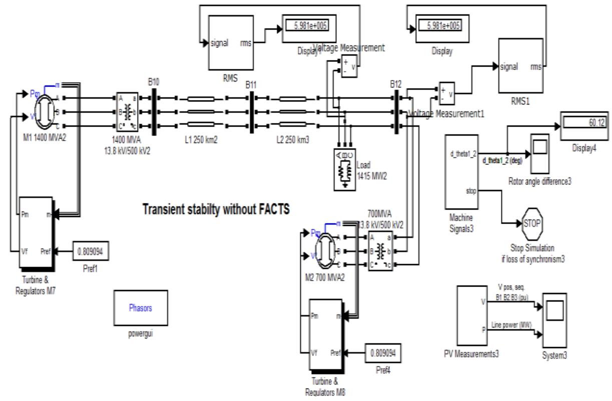
- ➢ The effect of UPFC is more pronounced when the controller is placed near faulted bus rather than placed at remote locations.
- ➢ UPFC helps in improving transient stability by improving critical clearing time.
- ➢ The transient stability is improved by decreasing first swing with UPFC and SVC.
- ➢ SVC helps in improving transient stability by improving critical clearing time.[4]

Control systems for FACTS controllers may have to be designed by using intelligent, adaptive digital controllers based on information obtained from wide area measurement networks. For systems using FACTS controllers, aiming for high levels of damping may not be a safe design goal for wide area control. Adequate damping over the largest realistic range of operating conditions may be a more desirable criterion to fulfil. The coordination of multiple FACTS controllers in the same system as well as in the adjacent systems must be investigated extensively and implemented to ensure the security of power system operation. Four FACTS controllers to be evaluated and compared are the SVC, the STATCOM, the SSSC, and the UPFC. The effects of different controllers can be expressed in terms of the critical clearing time (CCT). The controller parameters are selected with only consideration of maximizing the CCT. The CCT obtained for the different controllers are compared

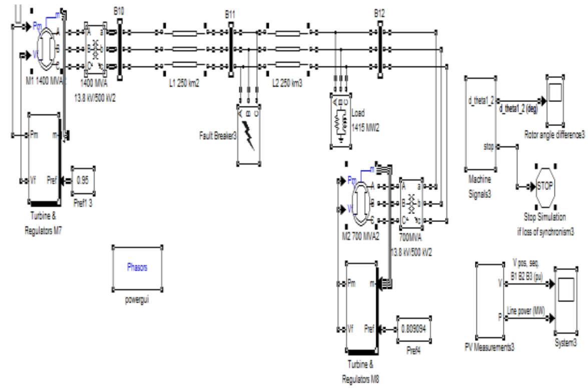
IV. MODEL & RESULTS

Transmission line MATLAB based models

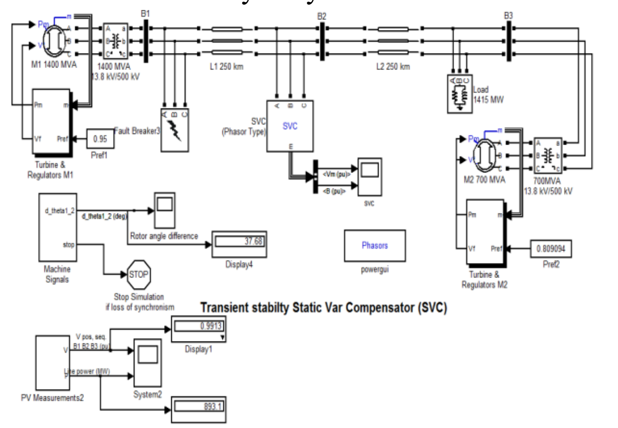
- ➢ Transient stability of system (without FACTS)



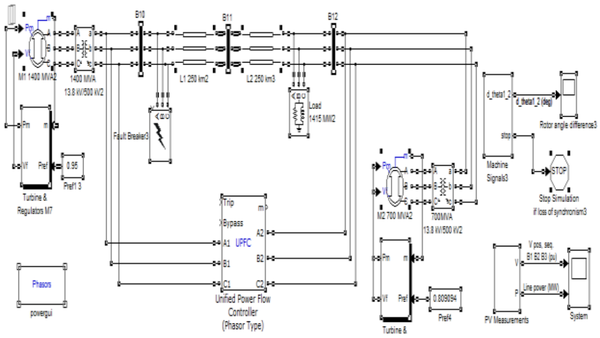
- ➢ Transient stability of system under fault condition (without FACTS)



- ➢ Transient stability of system with SVC Model

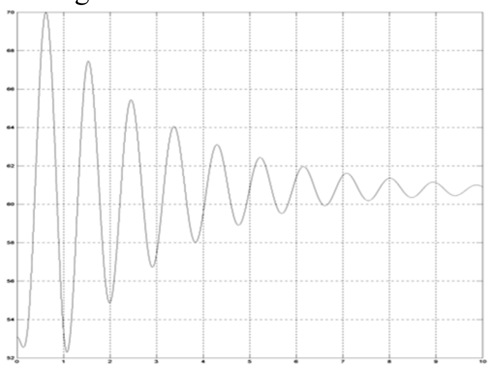


- ➢ Transient stability of system with UPFC Model

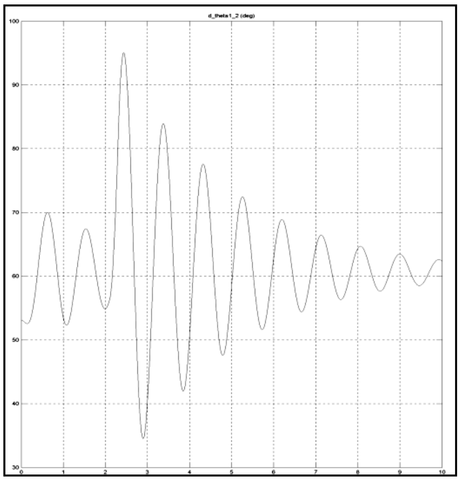


Results and Analysis

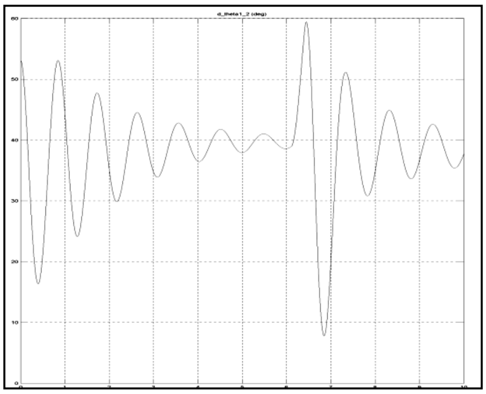
1) Power angle vs Time without FACTS and fault.



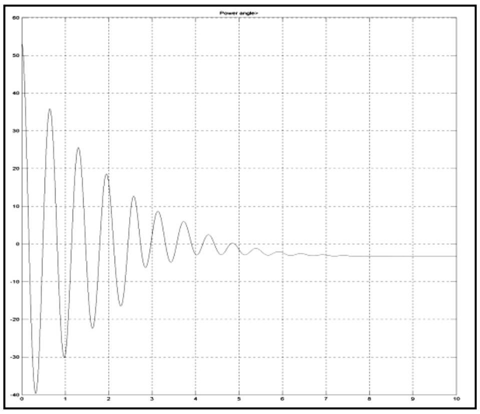
2) Power angle Vs Time with fault



3)Power angle Vs Time with SVC



4) Power angle vs Time with UPFC



Devices	Fault Time (sec)	Fault Clearing Time T_{cr}(sec)	Power Angle	Peak overshoot
Without fault	-	-	60.12	70.986
With fault	0.2 0.3 0.4	6.2 7.2 7.5	62.37 62.56 Unstable	95.06 118.52 Unstable
With SVC	0.2 0.3 0.4	4.1 4.4 4.6	38.76 38.96 39.35	53.076 56.09 64.442
With UPFC	0.1 0.2	2.9 3.2	8.085 8.121	40.10 40.20

V. CONCLUSION

The power system stability enhancement of a two area power system by various FACTS devices is presented and discussed. The dynamics of the system is compared with and without the presence of UPFC in the system in the event of a major disturbance. Then the performance of the UPFC for power system stability improvement is compared with the other FACTS device such as SVC. Among the shunt controllers, the STATCOM performs better than SVC. The UPFC is by far the best controller, as it provides independent control over the bus voltage and the line real and reactive power flows.

The functions of improving power quality and ensuring the continuity of electricity supply, the UPFC has been proposed to control simultaneously real and reactive power flows in the transmission line as well as to regulate the voltage bus using the FACTS. This device creates a tremendous impact on power system stability enhancement and loading of transmission lines close to their thermal limits. Thus, the device gives power system operators much needed flexibility to satisfy the demands that the deregulated power system imposes.

VI. REFERENCES

[1]. C. D. Schauder, L. Gyugyi, M. R. Lund, D. M. Hamai T. R. Rietman, D. R. Torgerson "Operation Of the Unified Power Flow Controller (UPFC) Under practical constaints" IEEE Transactions on Power Delivery, Vol. 13, No. 2, April 1998.

[2]. B. A. Renz, A. Keri, C. Schauder, E. Stacey, A. S. Mehraban L. Kovalsky, L. Gyugyi A. Edris "AEP UNIFIED POWER FLOW CONTROLLER PERFORMANCE" IEEE Transactions on Power Delivery, Vol. 14, No. 4, October 1999.

[3]. L. Y. Dong L., Zhang M. L. Crow "A New Control Strategy for the Unified Power Flow Controller" IEEE-2002.

[4]. Eskandar Gholipour and Shahrokh Saadate, "Improving of Transient Stability of Power Systems Using UPFC" IEEE Transactions on Power Delivery, VOL. 20, NO. 2, APRIL 2005.

[5]. A.Elkholy F. H. Fahmy A. A. Abou El-Ela, "Power System Stability Enhancement using The Unified Power Flow Controller" Proceedings of the 14th International Middle East Power Systems Conference (MEPCON'10), Cairo University, Egypt, December 19-21, 2010.

[6]. K. Manoz kumar Reddy "Improving the Transient and Dynamic stability of the Network by Unified Power Flow Controller (UPFC)" International Journal of Scientific and Research Publications, Volume 2, Issue 5, May 2012.

[7]. Reference book of Reactive Power Management by D.M.Tagare