COMPARATIVE ANALYSIS OF STATCOM AND SSSC FOR IMPROVING POWER QUALITY

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ABSTRACT

Reactive power compensation is an essential phenomenon in electrical power system. To do this in a better way is the need of the hour. As we know that the power system contains many equipment for its operation anywhere the performance of these components depends on the power transfer capability, voltage regulation and efficiency of transmission lines. To achieve better power transfer capability, good voltage regulation and high efficiency reactive power compensation has been done. This reactive power compensation can be done by many ways but and accurate. Over the years, the systems were extended and a growing number of generators and loads were interconnected. Because of the fast increasing consumption, the essential to transmit larger amounts of electric power over longer distances emerged which was met by raising the voltage levels of the power transmission lines. Further to develop exchanges between different utilities and to improve security, neighboring systems were connected. Herein this report we are comparing STATCOM along with SSSC for getting better result. The STATCOM is used for shunt compensation and SSSC is used for series compensation. First of all we develop the model for STATCOM along with SSSC after that we had done simulation for comparing the result. The models are developed using fuzzy logic. A preliminary study was carried out to various types of FACT devices installation effect on power system stability. Then we took STATCOM together with the SSSC to look forward the stability analysis on the system. We then adopted Fuzzy logic as a soft computing technique to increase the stability performance of our power system. We then made a simulation model for the same. Results with more stability were obtained which prove our work.

1.1 INTRODUCTION

The power system today is complicated network with hundreds of generating station along with the load centers which has being interconnected through transmission line. An electric power system could be subdivided into four stages as:

- Generation
- Transmission
- Distribution
- Utilization (load)

The simple structure of a power system has been presented in Fig 1.1 it composed of generating plants, along with a transmission system together with the distribution system. The interconnection of these substation is done through various transformers.

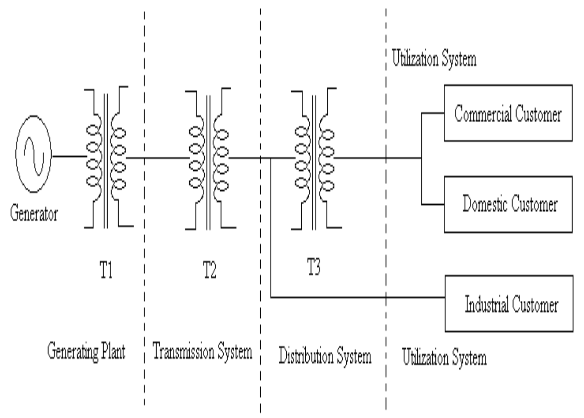

Fig 1.1 Typical Power Systems

Power Generation and Transmission is a complicated process, requiring the working of many devices of the power system in tandem to get the optimal output. The main motive is to get a main fragment is the reactive power in the power system along with that it has been obligatory to sustain the voltage to deliver the active power via lines. Loads like induction motor loads, dc motor load require reactive power for their operation. For the improvement of the workability of power transmission lines, we need to control this reactive power in an efficient way along with this has been known as reactive power compensation. Following are the characteristics to the issue of reactive power compensation: load compensation together with the voltage problem. Load compensation consists keeping a balance of actual power that has been drawn from the supply, together with the improvement in power factor for better voltage regulation of large fluctuating loads. Voltage problem contains of reduction of fluctuation of voltage fluctuation at a given terminal of the transmission line. Following are the kinds of compensation could be taken in usage: series along with shunt compensation. The phenomenon of compensation is to compensate the reactive power accurately as needed for example when the receiving end voltage is more it should absorb the additional voltage whereas if the receiving end voltage is lower than the required it should deliver the required amount of voltage to the transmission line for better operation. In last few years, static VAR compensators such as the STATCOM were developed. The STATCOM does the job of absorbing together with the generating reactive power as quickly as possible response together with the come under Flexible AC Transmission Systems. It permits an evaluation in transfer of apparent power through a transmission line, along with considerable improved voltage stability by the alteration of parameters which govern the power system[1].

II Analysis of Voltage Stability of Non-Linear Power System Static and Dynamic Analysis

Limitations of steady state power system studies (algebraic equations) are associated with stability of non-linear dynamic systems. If the dynamics act extremely fast to restore algebraic relations among the states, then it will be a good approximation to use the algebraic relations. In dynamic evaluation, the transition itself is of interest and it checks that the transition will lead to an acceptable operating condition.[3]

The voltage stability may be a dynamic development naturally, however the employment of steady state analysis ways is permissible in several cases. correct dynamic simulation is required for post-mortem analysis and therefore the co-ordination of protection and management. The voltage stability assessment of static and dynamic ways ought to be about to one another once applicable device models ar used and voltage instability doesn't occur throughout the transient amount of disturbance. In steady state voltage stability studies load-flow equations ar wont to represent system conditions. In these studies it's assumed that each one dynamics ar died out and all controllers have done their duty. Steady state voltage stability studies investigate long voltage stability. The results of those studies ar typically optimistic compared to dynamic studies.[4]

The time domain simulations capture the events together with the chronology resulting in voltage instability. This approach provides the foremost correct response of the particular dynamics of voltage instability once applicable modeling is enclosed. However, devices which can have a key role within the voltage instability embody those which can operate in an exceedingly comparatively very long time frame. These devices embody the over-excitation electric circuit of synchronous generator and therefore the on-load faucet changer. it's going to take minutes before a replacement steady state is reached or voltage instability happens following a disturbance. Static analysis is good for the majority of grid studies during which the examination of a large vary of grid conditions and an oversized variety of contingencies is needed.

The constancy of a linear system can be determined by studying Eigen values of the state matrix. The system is stable if all real components of chemist values square measure negative. If any real half is positive the system has been unstable. If any real half is zero we tend to cannot say something. the soundness of a non-linear system is determined by linearization of the system at the operational equilibrium. exploitation the primary terms of Taylor series growth, the perform is linearized. The state matrix may be a Jacobean matrix of perform determined by the state vector at the operation purpose. The Jacobean matrix describes the linear system that best approximates the non-linear equations on the point of the equilibrium. therein case the soundness of the non-linear system is studied just like the stability of linear systems within the neighborhood of operational equilibrium.[6]

Voltage stability may be a non-linear development and it's natural to use non-linear analysis techniques like bifurcation theory to review voltage collapse. Bifurcation describes qualitative changes like loss of stability. Bifurcation theory assumes that installation parameters vary slowly and predicts however an influence system becomes unstable. The variation of parameter modification the system slowly from one equilibrium to a different till it reaches the collapse purpose. The system dynamics should act a lot of quickly to revive the operational equilibrium than the parameter variations do to alter the operational equilibrium. Although voltage collapses are typically associated with discrete events such as large disturbances, device or control limits, some useful concepts of bifurcation theory can be reused with some care. Voltage collapses often have an initial period of slow voltage decline. Later on in the voltage collapse, fast dynamics can lose their stability in a bifurcation and a fast decline of voltage results.The complex conjugate eigenvalue pair is located at the imaginary axis at the Hopf bifurcation, in which case oscillation arises or vanishes. The Jacobean matrix has been non-singular at the Hopf bifurcation. There are also other bifurcations (e.g. pitchfork bifurcation) which are less likely to be found in general equations.

As the angle is increased, the power transfer increases up to a maximum. After a certain angle, nominally 90, a further increase in angle results in a decrease in power transferred. Hence a maximum steady-state power that can be transmitted between the two machines. The magnitude of the most power is directly proportional to the machine internal voltages and reciprocally proportional to the electrical phenomenon between the voltages, that contains electrical phenomenon of the cable connecting the machines and therefore the electrical phenomenon of the machines.

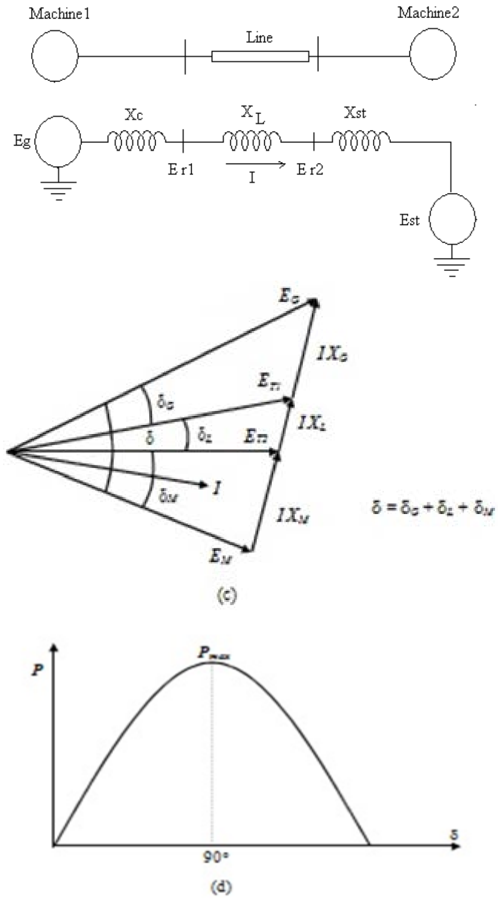

Fig. 2.1 Power transfer characteristics of Two Machine system Single Line

When there are two together with the more than 2 machines, their relative angular displacements have an effect on the interchange of power in an exceedingly similar manner. The limiting values of power transfers and angular separation area unit a elaborate perform of generation and cargo distribution. associate angular displacement of ninety degrees between any 2 machines (the nominal limiting price for a two-machine system) in itself has no explicit significance.

III Power Flow Problem Variables

Power flow is fundamentally a study of steady state operation of power framework. Power flow is a tool for investigating together with the computing these constraints. It essentially computes the subsequent four variables:

1. Voltage magnitude (V)
2. Voltage angle (δ)
3. Real power (P)
4. Reactive power (Q)

Out of four variables, two are variables are recognized or quantified at every single bus. Based on the quantified variables, there could be 3 kinds of buses in a power framework network which is as below-

1. Voltage controlled bus / Generator bus (PV bus)
2. Load bus (PQ bus)
3. Swing bus

3.1 Voltage Controlled bus

This is also recognized as generation bus and P-V bus, and n this bus the voltage magnitude which is corresponding to generation voltage along with the true including the active power P corresponding to its ratings has been stated.

Voltage magnitude has been kept persistent at a stated value through injection of reactive power. The reactive power generation Q along with phase angle δ of the voltage have to be calculated.

3.2 Load bus

This has been termed the P-Q bus along with at this bus the total injected power has been specified. That is active together with the reactive power injected into the network at this bus. It has been necessary to state only P along with Q at such a bus as at a load bus voltage could be acceptable to differ within the permissible value that is 5%. At this bus magnitude along with phase angle of the voltage have to be calculated.

3.3 Swing bus

One of the generation buses in the power system has been selected as a slack bus along with swing bus. The magnitudes along with phase angle have been stated at this bus. If slack bus is not stated then the generation bus with typically with a supreme active power P has been taken as mention bus. Therefore it could be convey that at every single bus out of four variables two variables have been identified along with two have been unspecified along with this could be exposed in tabular form.

IV. SIMUATION MODEL AND RESULTS

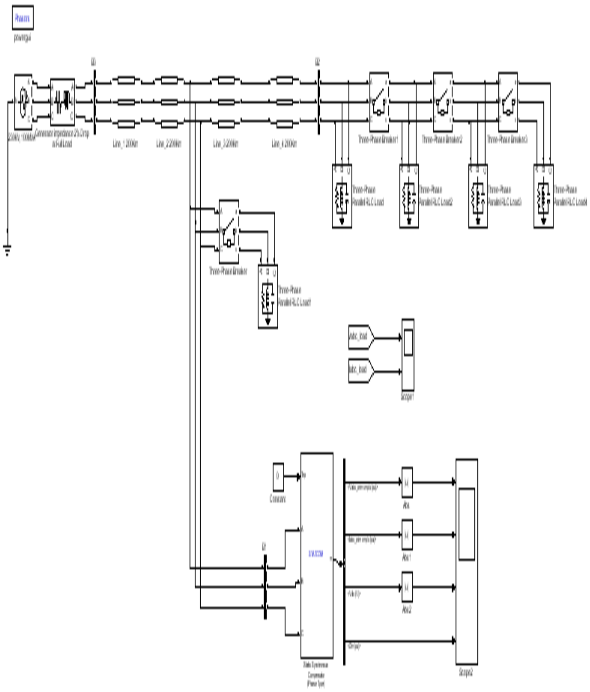

Fig 4.1 Diagram of STATCOM simulation done in Simulink

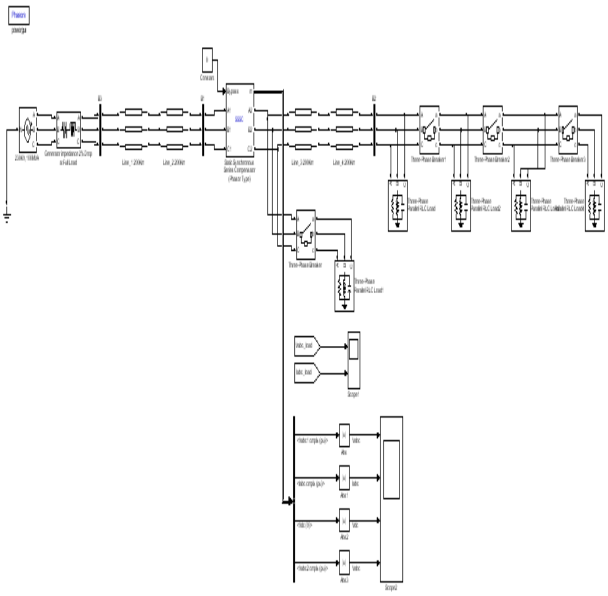

Fig 4.2 Diagram of SSSC simulation done in Simulink

Bus Type	Specifie	Unspecif	No of
Voltage	P,V	Q, δ	2(Ng-1)
Load bus	P,Q	V, δ	2(N-Ng)
Slack bus	V, δ	P,Q	2
Total	2N	2N	--

The difference lies in the output of the fuzzy logic controller from the conventional STATCOM along with SSSC device. The output will be more rectified and error free when fuzzy logic controller is introduced. The fuzzy controller regulates the Iq ref according to it's input error voltage between measured & reference & change in error.

Based on all the process that we have done we have done Three Analysis and the performance and output stability is calculated. The conditions are for different cases like for no load, on load variation in load and under faulty and abnormal conditions. The analysis is as follows:

Analysis 1: Voltage should be stable. There should be No Fault and the load should not vary.

- Source should be stable
- Fault should be removed
- Load should be varying from 25% to 100% in Steps

Proposed System:

In the proposed system we can see that the settling time is decreased, the peak variation is also decreased and the overall output regulation increases. We are taking the case when Voltage Should be stable. There should be No Fault and the load should not vary therefore the effect of voltage variation is minimized. We are taking an ideal case and we are taking no fault and no load therefore the output is also not varied by contingencies and other factors. Therefore the overall output will be stable.

Analysis 2: We want that Voltage should be stable and there should not be any faults and No load variation

- Voltage should be stable
- Fault should not occur.
- Load should be 25% at No variation
- Fault should not occur.
- Load should be 25% at No variation

Analysis 3: Now we want to have varying Voltage and the Fault to get Removed and the Load to be Stable.

- Voltage Step variation should be from 0.95 to 1.05
- Fault Should be Removed
- Load should be Stable at 25%

- Peak variation should be 0.1
- Settling Time should be 0.2
- Voltage regulation should be 0.01 Fuzzy logic controller and then we see the output variation.

To a great or extent the output parameters are stabilized and we see the settling time going down, the peak variation going down and regulation increasing.

These are all the exact variations as seen on the scope output in Matlab.

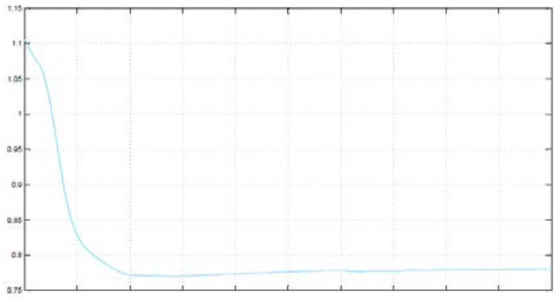

Fig 4.3 STATCOM output scope 1

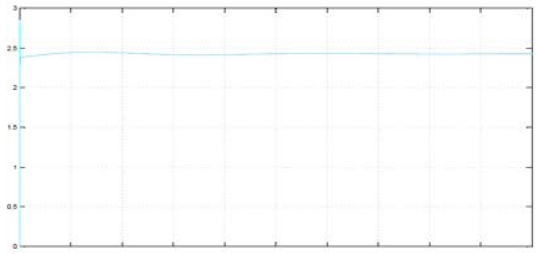

Fig 4.4 SSSC output scope 1

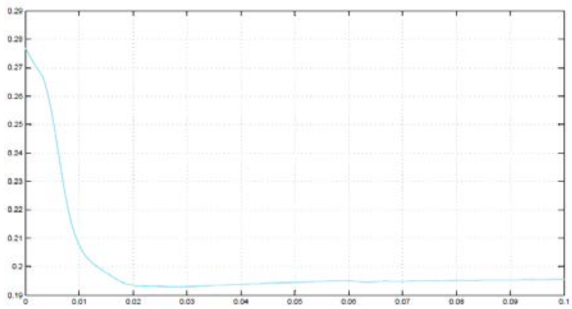

Fig 4.5 STATCOM output scope 1

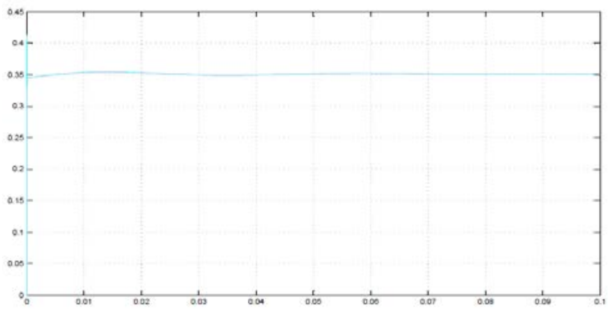

Fig 4.6 SSSC output scope 1

This shows the output waveform of load voltage and current. The output voltage (Vabc) in transient period varies from initial uptill 3 (approx) then settle down at 2.4 and then gain steady state.

Similarly output current waveform in transient period the spike in waveform is from initial uptill 0.41 . It settle down at 0.35 and then attain steady state with minute variations.

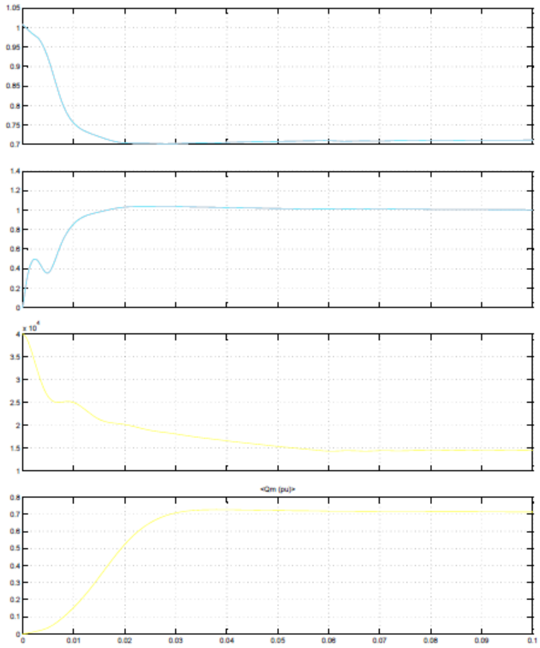

Fig 4.7 STATCOM output Scope 2

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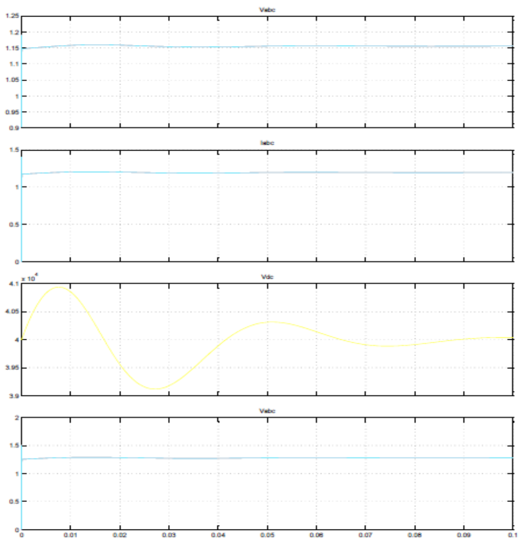

Fig 4.8 SSSC output Scope 2

This Shows the output waveform of Voltage, Current, DC Voltage attained after SSSC. In the output we attain Steady State which shows improved stability.

We observe that the dynamic response of the system with SSSC is quite satisfactory with a settling time of 1 sec. On the other hand, it takes 3 sec for the oscillations to settle down for the STATCOM. The shunt converter rating of the STATCOM to achieve the same level of damping is more (K, = 0.5). Simulation results have yield information on the dimensioning and the transient rating of the STATCOM along with SSSC is less for a practical application. For step change in mechanical input to the turbine SSSC damps the oscillations quickly compared to the STATCOM. Therefore there is a need for combined series along with shunt FACT device.

VI .CONCUSION

The UPFC is very effective for damping the oscillations when both the series along with shunt converters are modulated. When the shunt converter current is blocked K, = 0 the performance of the UPFC is comparable to that of the SSSC. Therefore UPFC with fuzzy, Neuro fuzzy can be designed to meet the criterion and to improve the stability.

V.REFERENCES

[1] [1]Kamboj, N. ; Kumar, N. ; Singh, A."A comparative study of synchronous resonance using SSSC and STATCOM**”,** Power Electronics (IICPE), 2012 IEEE 5th India International Conference on 2012 , Page 1 – 6.

[2]Amara, S. ; Hsan, H.A. "Power system stability improvement by FACTS devices: A comparison between STATCOM, SSSC and UPFC”. Renewable Energies and Vehicular Technology (REVET), 2012 First International Conference 2012, Page 360 - 365.

[3] Chung T.S., Li Y.Z., "A Hybrid GA Approach for OPF with Consideration of FACTS Devices", IEEE Power Engineering Review, Vol. 21, No. 2, pp.47-57, Feb. 2001.

[4]C. H. Liang, C. Y. Chung, K. P. Wong and X. Z. Duan “hybrid algorithm of differential evolution and evolution programming for optimal reactive power flow”, generation, distribution and transmission IET vol.4, pp. 84-93, 2010**.**

[5]Zarate, L.A.Ll. ; Castro, C.A. ; Ramos, J.L.M. Ramos, E.R. "Fast computation of voltage stability security margins using nonlinear programming techniques”. Power Systems, IEEE Transactions on Volume: 21, Issue: 1 2006, Page(s): 19 – 27.

[6]Sode Yome, A.; Mithulananthan, N.; Lee, K.Y."A maximum loading margin method forstaticvoltagestabilityinpowersystems".Power Systems,IEEETransactions on Volume:21,Issue:2,2006,Page(s):799-808.

[7] Smon, I. ; Verbic, G. ; Gubina, F."Local voltage-stability index using tellegen's Theorem" Power Engineering Society General Meeting, 2007. IEEE Page(s): 1

[8] Sheng Li ; Qi Zhao ; Cheng Chen ; Yan Xu. "A comparative study on voltage stability bifurcation control ability of SVC and STATCOM". Electricity Distribution (CICED), IEEE, 2012 China International Conference on 2012, Page(s): 1 - 4

[9] Zabaiou, T. ; Dessaint, L.-A. ; Kamahi "Preventive control approach for vol[1]. stability improvement using voltage stab[5]. constrained optimal power flow based on st[5] line voltage stability indices". Generat Transmission & Distribution, IET Volume: 8, Issue: 5, 2014, Page 924 – 934.

[10] Brusilowicz,,B. ; Rebizant,W. ; Szafran, J."A new method of voltage stability margin estimation based on local measurements". Advanced power system system Automation and Protection (APAP), 2011 International Conference on Volume: 3 ,2011 , Page(s): 2443 – 2447.

[11]Jing Zhang ; Wen, J.Y. ; Cheng, S.J. ; Jia Ma . "A Novel SVC Allocation Method for Power System Voltage Stability Enhancement by Normal Forms of Diffeomorphism" Power Systems, IEEE Transactions on Volume: 22, Issue 4 , 2007 , Page(s):1819-1825.

[12]Abdel-Moamen, M.A. ; Padhy, N.P. "Newton Raphson TCSC model for power flow solution of practical power networks". Power Engineering Society Summer Meeting, 2002, IEEE Volume: 3, 2002, Page(s):1488-1493.

[13] VanHertem, D. ; Driesen, J. "A TCSC model for the power flow solution of the power transmission system of Vietnam". Universities Power EngineeringConference (UPEC), 2009 Proceedings of the 44th International IEEE, 2009, Page 1 - 5

[14] Ambriz-Perez, H. ; Acha, E. ; Fuerte-Esquivel, C.R. "Closure to discussion of "advanced SVC models for newton raphson load flow and newton optimal power low studies". Power Systems, IEEE Transactions on Volume: 16, Issue 4, 2001, Page 947 – 948.

[15] Mishra, S. ; Dash, P.K. ; Panda, G. "TS-fuzzy controller for UPFC in a multi machine power system", Generation, Transmission and Distribution, IEE Proceedings- ,Volume:147,Issue:1, 2000 ,Page 15-22 .

[16]Huey Yang Horng."Leadlag compensate or design based on greedy particles warm optimization", Next Generation Electronics (ISNE), 2013 IEEE International Symposium on 2013,Page579–581.

[17] Babu, A.V.N. ; Sivanagaraju, S. " Mathematical modelling, analysis and effects of interline power flow controller (IPFC) parameters in power flow studies". Power Electronics (IICPE), 2010 India International Conference on 2011 , Page(s): 1 – 7 Volume: 145, Issue: 5, 1998 , Page 493 - 498