Comparative Study of Statcom and Sssc for Enhancing Power Quality in Transmission Line with Fuzzy Logic Control

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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 is done. This reactive power compensation can be done by many ways but due to the development of power electronic devices we can achieve this compensation quite fast and accurate. Over the years, the systems were extended and a growing number of generators and loads were interconnected. Due to the fast increasing consumption, the need 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. Here in this report we are comparing STATCOM and 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 and 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 and 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. Then we compared the results. After comparing the we found that SSSC damp the oscillation more quickly than STATCOM. But there is a need for combined series and shunt FACT device operation in power system for getting satisfactory result which can be achieved by applying UPFC.

I. INTRODUCTION

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

- Generation
- Transmission
- Distribution
- Utilization (load)

The basic structure of a power system is as shown in Fig 1.1 it composed of generating plants, a transmission system and distribution system. The interconnection of these substation is done through various transformers.

![Fig 1.1 Typical Power Systems](image-url)
II. Flexible Ac Transmission Systems (FACTS)

In general, Flexible AC Transmission Systems (FACTS) is a new technology. It has the principle role of enhancing and power transfer capability in AC systems. This opportunity for controlling power and enhancing the usable capacity can be achieved by using FACTS devices. The possibility that current in a line can be controlled at a reasonable cost enables a large potential of increasing the capacity of existing lines with conductors, and use of FACTS controllers to enable corresponding power flow through such lines under normal and contingency conditions.

These opportunities arise through the ability of FACTS Controllers to control the interrelated parameters that govern the operation of transmission systems including series impedance, shunt impedance, current, voltage, phase angle and the damping of oscillations at various frequencies below the rated frequency. The FACTS technology is not a single high-power Controller, but rather a collection of Controllers, A well-chosen FACTS Controller can overcome the specific limitations of a designated transmission line or a corridor. Because all FACTS Controller represent applications of the same principle, their production can be used to take advantage of microelectronic chips and circuits, the SCR or high-power transistor is basic element for a variety of high-power FACTS controllers.

III CLASSIFICATION OF POWER SYSTEM STABILITY

Power system stability is classified above as rotor angle and voltage stability. A classification of power system stability based on time scale and driving force criteria is presented in Table 3.1. The driving forces for an instability mechanism are named generator-driven and load-driven. It should be noted that these terms do not exclude the effect of other components to the mechanism. The time scale is divided into short and long-term time scales.

IV. DESCRIPTION OF SIMULATION (SIMULATION MODEL)

To understand the output of the simulation we have firstly considered a system in which we have not included STATCOM and SSSC and we go through the output of the whole system. We have a variable input voltage and without STATCOM and SSSC, the output varies unevenly and the three factors we are considering varies very much. Due to this we understand the need of a simple Capacitor bank or FACTS devices so that proper reactive power can be injected and we get the output stable, again we consider the output stability in terms of three factors Settling time, Peak Variation & regulation. Now further to make sure that the output is more stable we introduce 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. This indicates that by using the STATCOM and SSSC and with the use of Fuzzy logic controller output can be stabilized. We have taken 3 cases to study in detail the outcome of using STATCOM and SSSC with fuzzy logic controller.
Where to introduce fuzzy logic controller? Fuzzy logic controller is introduced in the STATCOM and SSSC model. It is introduced in the feedback of the AC & DC voltage regulator.

This is as shown below

![Inside view of STATCOM where fuzzy controller is to be introduced](Fig 4.1)

![Inside view of SSSC where fuzzy controller is to be introduced](Fig 4.2)

Inside the AC & DC voltage regulator we introduce the fuzzy logic controller. In the diagram below we can see firstly the simple STATCOM without fuzzy logic controller and then STATCOM with fuzzy logic controller. Capacitor bank or FACTS devices so that proper reactive power can be injected and we get the output stable, again we consider the output stability in terms of three factors Settling time, Peak Variation & regulation. Now further to make sure that the output is more stable we introduce Fuzzy logic controller and then we see the output variation. To a greater extent the output parameters are stabilized and we see the settling time going down, the peak variation going down and regulation increasing.

![STATCOM without fuzzy logic controller](Fig 4.3)
Fig 4.4 STATCOM with fuzzy logic controller
SSSC for the improvement of AC Regulation block in Simulink. Then the comparison is performed for same parameters as explained in first part. The fuzzy controller regulates the $I_{qref}$. According to it’s input error voltage between measured & reference & change in error.

Fig 4.5 SSSC without fuzzy logic controller

Fig 4.5 SSSC with fuzzy logic controller
The difference lies in the output of the fuzzy logic controller from the conventional STATCOM and SSSC device. The output will be more rectified and error free when fuzzy logic controller is introduced. The fuzzy controller regulates the $I_q$ 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 4.8 Fuzzy rule viewer of SSSC

Fig 4.9 Fuzzy rule viewer of SSSC

Fig 4.10 STATCOM output scope 1
This shows the output waveform of load voltage and current. The output voltage ($V_{abc}$) in transient period varies from initial up till 3 (approx) then settle down at 2.4 and then gains steady state. Similarly output current waveform in transient period the spike in waveform is from initial up till 0.41. It settle down at 0.35 and then attains steady state with minute variations.
This shows the output waveform of Voltage, Current, and 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 ($K_c = 0.5$). Simulation results have yield information on the dimensioning and the transient rating of the STATCOM and 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 and shunt FACT device.

**V. CONCLUSIONS AND FUTURE SCOPE**

In this work 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 and 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.
Then we compared the results. After comparing the we found that SSSC damp the oscillation more quickly than STATCOM. But there is a need for combined series and shunt FACT device operation in power system for getting satisfactory result which can be achieved by applying UPFC.

**FUTURE WORK**

The UPFC is very effective for damping the oscillations when both the series and shunt converters are modulated. When the shunt converter current is blocked $K_s = 0$ 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.

**REFERENCES**


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