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# Comparative Analysis of Power Quality Improvement Using STATCOM and SSSC in Distribution System

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**ABSTRACT**

This paper presents the comparison of different Flexible AC Transmission System (FACTS) controllers and describes the methods of improving quality of power in Distribution system using Flexible AC Transmission System (FACTS) controller based on Adaptive Neuro Fuzzy Inference System. Power quality problems can be eliminated by many methods but most efficient solution to overcome these problems by using FACTS devices, Namely Static Synchronous Series Compensator (SSSC), Static Synchronous Compensator (STATCOM) were utilized in this work. Adaptive Neuro Fuzzy Inference System (ANFIS) technique used to determine the value of condenser connected to the FACTS. The proposed method in this paper is tested on IEEE 14 bus system as well as IEEE 30 bus system. The work is done using MATLABSIMULATION SOFTWARE

***Keywords:*** SSSC, STATCOM, ANFIS, FACTS

## 1. INTRODUCTION

Power quality means the fitness of electric power to consumer devices Synchronization of the voltage frequency and phase allows the electrical system to function more efficient manner without remarkable loss of performance or system[13]. If the system has good power quality means the equipment which are connected operates correctly without any disturbances. Poor power leads an electrical device may malfunction or not operate at all. There are many reasons in which electric power can be of poor quality. Power quality is a convenient term for many, it is the quality of the voltage rather thapower or electric current.

### 1.1. Power Quality Issues

Power Quality issues are of most concern nowadays. Due to their non-linearity, all these loads cause disturbances in the voltage waveform. There are many power quality problems. Some of it has voltage sag, swell, voltage spike, harmonic Distortion, blackout, brownout and Transient etc. Flexible AC Transmission System is the main device to mitigate the power quality problem [15]. The two main objectives of FACTS device are to increase the capability of transmission capacity of lines.

## 2. STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)

The Static Synchronous Series Compensator injects a voltage in series with the transmission line where it is connected[17]. Static Synchronous Series Compensator is a modern power quality FACTS device that employs a voltage source converter connected in series with transmission line through a series transformer. The SSSC operates like a controllable series capacitor and series inductor.

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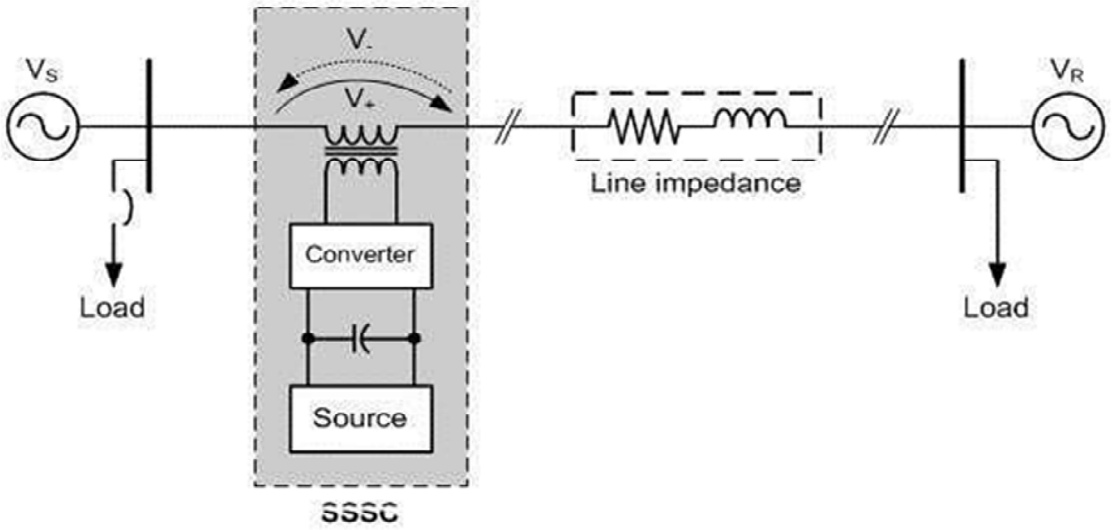


**Figure 1: Structure of SSSC**

Static Synchronous Series Compensator has three basic components they are voltage source converter transformer and energy source [16, 20]. The SSSC injects the compensating voltage in series with the transmission line irrespective of line current. The SSSC operated with the proper energy supply can inject a voltage component, which is of the same magnitude but opposite phase angle with the voltage developed across the line. The static series compensator provides fast control for power quality related problems.

## 3. STATIC SYNCHRONOUS COMPENSATOR(STATCOM)

Static synchronous compensator is one of the flexible alternating current transmission systems (FACTS) device family STATCOM is used to control the amount and direction of flow of the reactive power exchanged with the ac power system.[12]

The STATCOM is a shunt device .If output voltage of STATCOM (VVSC) is in phase with bus voltage and i.e. VVSC is greater than Vbus, STATCOM provides reactive power to system [9]. If STATCOM voltage is smaller thanVbus, STATCOM absorbs reactive power from system.

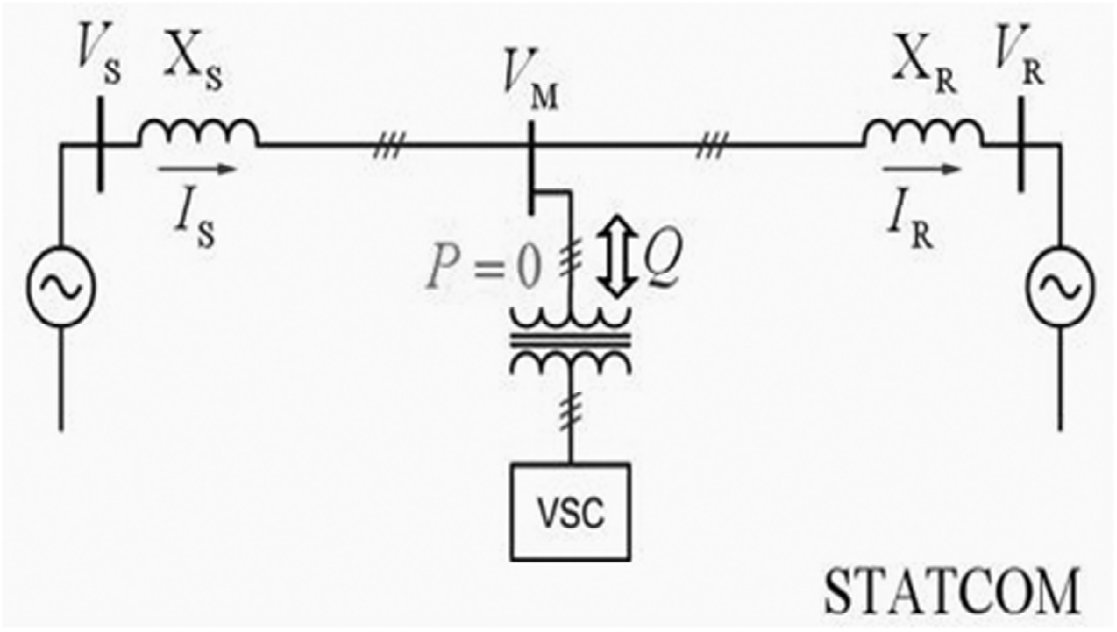


**Figure 2: Structure of STATCOM**

The Power equations in STATCOM,

$$P = \frac{V_{bus} V_{VSC}}{X_L} \sin \delta$$

$$Q = \frac{V_{bus}^2 - V_{bus} V_{VSC} \cos \alpha}{X_L}$$

## 4. ADAPTIVE NEURO FUZZY INFERENCE SYSTEM (ANFIS)

A neuro fuzzy technique called as Adaptive network based fuzzy inference system has been used as a prime tool in the present work. Adaptive network based fuzzy inference system is a neuro fuzzy technique where the fusion is made between the neural network and the fuzzy inference system[6]. ANFIS methodology comprises of a system of fuzzy logic and neural network technique.

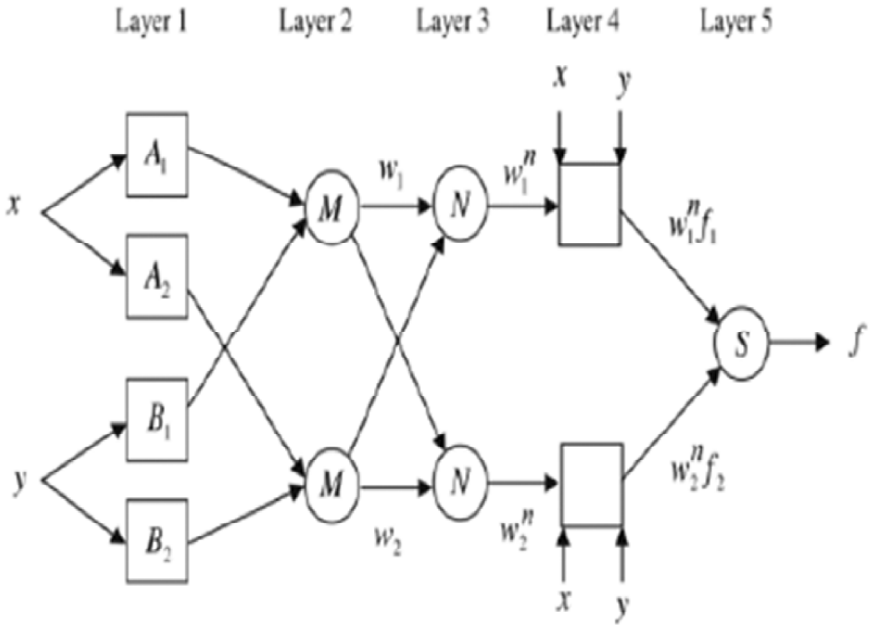


**Figure 3: Architecture of ANFIS**

## 5. SIMULATION RESULTS

**Table 1**
**For IEEE 30 bus system without ANFIS**

| *Voltage at bus* | *Normal voltage* | *When fault occurred* | *By Using STATCOM* | *By using SSSC* |
|---|---|---|---|---|
| 30 | 5.4 KV | 4.4 KV | 5.350 KV | 4.850 KV |
| 30 | 4.2 KV | 3.2 KV | 4.150 KV | 3.650 KV |

**Table 2**
**For IEEE 30 bus system without ANFIS**

| *Voltage at bus* | *Normal voltage* | *When fault occurred* | *By Using STATCOM* | *By using SSSC* | *By using STATCOM Applying ANFIS algorithm* | *By using SSSC Applying ANFIS algorithm* |
|---|---|---|---|---|---|---|
| 30 | 5.4 KV | 4.4 KV | 5.350 KV | 4.850 KV | 5.390 KV | 5.360 KV |
| 30 | 4.2 KV | 3.2 KV | 4.150 KV | 3.650 KV | 4.190 KV | 4.160 KV |

**Table 3**
**For IEEE 14 bus system without ANFIS**

| *Voltage at bus* | *Normal voltage* | *When fault occurred* | *By Using STATCOM* | *By using SSSC* |
|---|---|---|---|---|
| 14 | 4.6 KV | 3.6 KV | 4.550 KV | 4.050 KV |
| 14 | 3.2 KV | 2.2 KV | 2.650 KV | 2.650 KV |

**Table 4**
**For IEEE 30 bus system without ANFIS**

| *Voltage at bus* | *Normal voltage* | *When fault occurred* | *By Using STATCOM* | *By using SSSC* | *By using STATCOM Applying ANFIS algorithm* | *By using SSSC Applying ANFIS algorithm* |
|---|---|---|---|---|---|---|
| 14 | 4.6 KV | 3.6 KV | 4.550 KV | 4.050 KV | 4.590 KV | 4.560 KV |
| 14 | 3.2 KV | 2.2 KV | 3.150 KV | 2.650 KV | 3.190 KV | 3.160 KV |

## 6. CONCLUSION

In this work, SSSC and STATCOM are used to improve power quality. This method was tested on the IEEE 30 bus and IEEE 14 bus system. The best type of FACTS used to improve power quality is STATCOM because of it able to mitigate the fault quickly as compared to SSSC, it can also the cover the capacitive and reactive power demand and reduce the harmonic distortion. Adaptive Neuro-Fuzzy Inference System (ANFIS) is a controller used to boost up the output voltage of SSSC and STATCOM and it also used to find the value of capacitor connected in the FACTS. The result shows that the power quality improved.

## REFERENCES

[1] M.Z. Elsadek, et al., “Flexible AC Transmission Systems (FACTS) for power quality improvement of unbalanced systems suffering from voltage instability”, MEPCON’2001, University of Helwan, Cairo, Egypt.

[2] Mohamed A. H. El-sayed, et al., “Power system voltage stability improvement by SVC”, MEPCON’2003, Shebin Elkom, Egypt.

[3] H.O. Bansal et al., “Optimal Location of FACT Devices to Control Reactive Power”, International Journal of Engineering Science and Technology, 2010, Vol. 2(6), 2010, 1556-1560.

[4] Aswani Kumar, “Optimal Location of UPFC and Comparative Analysis of Maximum Loadability with FACTS in Competitive Electricity Markets”, 7thWSEAS International Conference on Electric Power Systems, High Voltages, Electric Machines, 2007, Venice, Italy.

[5] Chintan R. Patel, Sanjay N. Patel and Dr. Axay J. Mehta, “Static Synchronous Series Compensator (SSSC): An approach for reactive powercompensation for the transmission system. National Conference on Recent Trends in Engineering & Technology 2011.

[6] K. Lokanadham, “Optimal Location of FACTS Devices in Power System by Genetic Algorithm”, global journal of researches in engineering, April 2010, Vol. 10 Issue 1 (Ver1.0), April 2010.

[7] Dr. C. Christober Asir Rajan “Design and Simulation of STATCOM to Enhance the Voltage Stability of a Wind Power System” IEEE International Conference 2015.

[8] Teleke, S.Yazdani, A. Gudimetla, B. Enslin, J. Application of STATCOM for power quality improvement Power Systems Conference and Exposition (PSCE), 2011 IEEE/PES.

[9] Aguero, J.L.; Fac. de Ingenieria, Universidad Nacional de La Plata ; Issouribehere, F.; Battaiotto, P.E. STATCOM modeling for mitigation of voltage fluctuations caused by electric arc furnaces Power Engineering Society General Meeting, 2006. IEEE.

[10] Shervin Samimian Tehrani1, Peyman Salmanpour Bandaghiri2 “Shunt Compensation for Improvement of Voltage Stability Using Static Synchronous Compensator (STATCOM) for Various Faults in Power System” International Journal of advanced research in Electrical, Electronics and Instrumentation Engineering

[11] X.P. Zhanga, E. Handschinb, M. Yao “Multi-control functional static synchronous compensator (STATCOM) in power system steady-state operations” Electric Power Systems Research Volume 72, Issue 3, 15 December 2004, pp. 269-278.

[12] Bhim Singh, R. Saha, A. Chandra, Static synchronous compensators (STATCOM): a review IET power electronics 2(4):29324 · AUGUST 2009.

[13] Power Quality Wikipedia

[14] Arton Ndokag, Augusto Di Napoli "Behaviour of an front end in presence of voltage sags" International Symposium on Power Electronics 2014.

[15] R.K. Rojin "A review of power quality problems and solutions in electrical power system" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 11, November 2013.

[16] El-Zonkoly A. (2006), Optimal Sizing of SSSC Controllers to Minimize Transmission Loss and a Novel Model of SSSC to Study Transient Response.

[17] P. Suman Pramod Kumar, N. Vijaysimha, C.B. Saravanan "static synchronous series compensator for series compensation of ehv transmission line" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 7, July 2013.

[18] S. N. Singh, Senior Member, IEEE, and I. Erlich, Member, IEEE "Locating Unified Power Flow Controller for Enhancing Power System Loadability".

[19] Bin Ye; Coll. of Electr. Eng., Zhejiang Univ., Hangzhou, China; Chuangxin Guo; Yijia Cao **"**Short-term load forecasting using a new fuzzy modeling strategy" IEEE explore Digital library 2004.

[20] G.P. Ramesh, A.J.S. Ali, "Comparison of Boost and Interleaved Boost Converters for Wind Energy System", International Journal of Scientific & Engineering Research, vol. 5, Issue. 4, pp. 83-86, 2014.