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A SURVEY OF FACTS CONTROLLERS APPLICATIONS TO NIGERIAN TRANSMISSION SYSTEM

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ABSTRACT

This paper is a presentation of a review of the incorporation of FACTS controllers such as SVC, STATCOM, TCSC, SSSC, VSC-HVDC and UPFC on the Nigerian 330kV transmission system for the enhancement of the operations of the transmission system. Selected publications were scrutinized and conclusions were drawn from the results of the applications of these controllers on the system. This publication will serve as a reference for power system operators and will inform researchers on how much needs to be done in the incorporation of FACTS controllers on the Nigerian transmission system.

KEYWORDS: FACTS Controllers, SVC, STATCOM, SVC, VSC-HVDC, UPFC

1. INTRODUCTION

The supply of electricity involves three stages: generation, transmission and distribution. This determines the organization of electric utility companies in a deregulated economy such as Nigeria. The transmission system acts as the ‘‘middleman’’ between generation and distribution. The ability of the transmission system to transfer the generated power efficiently to the loads in the distribution system determines how efficient a power system is. In recent years, energy, environment, right-of-way and cost problems have delayed the construction of both generation facilities and new transmission lines. This has necessitated a change in the traditional power system concepts and practices; better utilization of existing power systems has become imperative [1].

Flexible Alternating Currents Transmission System (FACTS) is static equipment used for the AC transmission of electrical energy. It is meant to enhance controllability and increase power transfer capability. It is generally a power electronics based device [2]. Introduction of FACTS controllers has been a practical solution and offers the required better utilization of the existing power system. The key objectives of FACTS technology are to [3]

- Increase transmission capacity allowing secure loading of the transmission lines up to their thermal capacities.
- Enable better utilization of available generation, transmission, and
- Contain outages from spreading to wider areas.

There are various power system analyses that are used to evaluate the performances of electrical power system; these include, power flow analysis, optimal power flow analysis, contingency analysis, transient stability analysis, fault analysis, etc. FACTS controllers have been applied in the various power system analyses [4], [5], [6], [7], [8], [9]. In all the literatures, it has been found that FACTS controllers have greatly enhanced the performances of power systems.

This paper is organized as follows: Section 2 presents the types of FACTS controllers that have been developed. Section 3 presents the overview of the Nigerian power system. Section 4 presents the review of FACTS controllers incorporated into the Nigerian 330kV transmission system and Section 5 presents the conclusion.

2. CLASSIFICATIONS OF FACTS CONTROLLERS

FACTS devices have been classified under the headings of First Generation and Second Generation of FACTS. Some of FACTS controllers for enhancing power systems are discussed.

2.1 Static VAR Compensator (SVC)

SVC is a first generation FACTS device. It is an electric device for providing fast-acting reactive power on high-voltage electricity transmission networks. SVC can control voltage at the required bus thereby improving the voltage profile of the system. The primary task of SVC is to maintain the voltage at a particular bus by means of reactive compensation [2], [6], [9].

2.2 Thyristor Controlled Series Capacitor (TCSC)

TCSC is also a first generation FACTS controller. It is one of FACTS controllers that is increasingly applied to long transmission lines by the utilities in modern power systems [6]. It has 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, damping power oscillations and enhancing transient stability [6].

2.3 Static Synchronous Compensator (STATCOM)

STATCOM is a second generation FACTS controller. It is a regulating device based on a power electronics voltage-source controller [2], [8]. The primary function of STATCOM in a power system is to increase transmission capability in a given transmission network [8]. Usually, a STATCOM is installed to support electricity network that have poor power factor and often poor voltage regulation. It is also used to for voltage stability. STATCOM provides better damping characteristics than SVC as it is able to transiently exchange active power with the system [2].

2.4 Static Synchronous Series Compensator (SSSC)

SSSC is a second generation FACTS controller [2]. This device works the same way as STATCOM. SSSC is able to exchange active and reactive power with the transmission system, The primary purpose of SSSC is to control power flow in steady-state. It can also improve transient stability of a power system [6].

2.5 Unified Power Flow Controller (UPFC)

A UPFC is a second generation FACTS controller [2]. It 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 [2], [7]. UPFC is also the most versatile FACTS controller that can be used to improve steady state stability, dynamic stability and transient stability [10].

2.6 Voltage Source Converter – High Voltage Direct Current (VSC-HVDC)

VSC-HVDC is a new type of FACTS controller. Its characteristics make the VSC-HVDC a very good candidate in the following emerging engineering applications areas: converting renewable energy sources which may be located in remote areas from the grid; off-shore wind generation including delivery of electricity to islands; feeding of electric power to large and rapidly growing cities; interconnecting weak points of otherwise independent subsystems [11].

3. OVERVIEW OF NIGERIAN TRANSMISSION SYSTEM

The Nigerian transmission system is radial system consisting of 5,650km of 330kV transmission lines. Parts of the problems on the power system include transmission capabilities inefficiency and its radial transmission nature which does not allow for system reliability [12]. Another problem is the length of the transmission lines; there are transmission line loses due to the long distances between generating stations and load Centre [13], [14]. The transmission network is characterized by several outages leading to disruption in the lives of its citizenry [15].

[16] Suggested the incorporation of FACTS controllers in Nigerian power system as a measure that can be taken to significantly minimize the impacts of events on the power system and to help mitigate the risk of widespread blackouts. [11] Reported that little work has been done in the incorporation of the FACTS controllers for enhancing power system operations of the Nigerian 330kV transmission system.

4. FACTS CONTROLLERS INCORPORATED INTO NIGERIAN 330KV TRANSMISSION SYSTEM

In [17] the optimal location of FACTS controllers has been performed on the Nigerian 330kV transmission system using UPFC. The main objective was to develop an approach to find and choose the optimal location of FACTS device (i.e. UPFC) based on the sensitivity of the total system active power loss with respect to the control variables of the UPFC in Nigerian grid system. Sensitivity analysis was introduced to determine the indices of each line for the optimal sitting of the UPFC aimed at enhancing voltage stability of Nigerian grid network. The transmission line from Jos to Gombe was found the best location for the UPFC as it has the largest value of sensitivity index. It was concluded that the UPFC with coordinated controllers can greatly improve and enhance the static and dynamic voltage stability margins and hence active power loss reduction.

[18] Presented the results of power flow analysis of Nigerian power system incorporating FACTS controllers such as STATCOM, VSC-HVDC and UPFC. The power flow results of the Nigerian 24-bus 330kV transmission system without FACTS controllers showed that the voltage magnitudes at some buses are lower than the acceptable limit and that the system has a high total active power loss. A MatLab based program, Flexible Alternating Current Transmission System Power Flow (FACTSPF) for steady state analysis of power system was developed. Application of the FACTS controllers in the Nigerian system resulted in the voltage profile being brought within the acceptable limit. In addition, FACTS controllers also assisted in reducing the high power losses on the power system depending on the type and number of FACTS controllers installed. The technical benefits derivable from the incorporation of STATCOM, VSC-HVDC and UPFC in the Nigerian power system was demonstrated in this work.

[19] Researched on the effective performances of Power System Stabilizer (PSS) and STATCOM considered separately in damping oscillations on the 330kV North-Central network of Nigerian grid system. The aim was to determine a better damping controller between PSS and STATCOM. Placement of the STATCOM was done optimally using generic algorithm, whereas, the location of the PSS in requisite generator is determined by the eigenvalues analysis and damping coefficient. It was observed that the damping effect of PSS was limited to the swings of the generator and has little or no effect on the inter-area oscillations while STATCOM has pronounced effect on dmping the inter-area oscillations.

The conclusion was that STATCOM has improved the network performance in damping oscillations of the active power on buses than PSS.

In [20] UPFC was used to relieve power system congestion on a 330/132kV section of Nigerian grid system. The aim was to develop a typical model that can be implemented with real time parameters in a segment of the Nigerian national grid system for congestion management and optimal power flow. Simulation results showed the effectiveness of UPFC in controlling power flow and corresponding relieve of the transmission line to guarantee optimal power transfer leading to decongestion. It was concluded that UPFC is a device for a truly deregulated power generation environment so that no generating station is short changed due to line congestion and with this, a truly competitive and reliable power supply can be achieved.

5. CONCLUSIONS

This paper has x-rayed and presented a comprehensive review of FACTS controllers applications on the Nigerian transmission system based on the publications available. It is observed that few publications are available translating to the fact that few works have been carried out on the incorporation of FACTS controllers on the Nigerian transmission system. From the review carried out, it is shown that incorporation of FACTS controllers on the Nigerian grid system will greatly enhance the performance of the transmission system and the inherent problems characterizing the grid system will be minimized. It is recommended that research works in this field should be vigorously encouraged and sponsored by the concerned authority and government. It is also recommended that research should be carried out on the incorporation of new FACTS controllers on the Nigerian Transmission system; this will further enhance the performance of the Nigerian transmission grid and improving the quality of lives of Nigerian.

REFERENCES

1. Gyugyi, L: ‘‘Power Electronics in Electric Utilities: Static Var Compensator’’, IEEE Proceedings, Vol. 76, No. 4. 1988.
2. Alok, K.M. and Amar, K.B: ‘‘Power System Stability Improvement Using FACTS Devices’’, International Journal of Modern Engineering Research, Vol. 1, Issue 2. Pp 666 – 672. 2012.
3. Acha, E., Fuerte-Esquivel, C., Ambriz-Perez, H., and Angelles-Camach, C: FACTS :Modelling and Simulation in Power Networks, John Willey and Sons, Ltd. 2004.
4. Bindeshwar, S., Sharma, N., Tiwari, A., and Singh, S: ‘‘Incorporation of FACTS Controllers in Newton-Raphson Load Flow for Power Flow Operation, Control and Planning: A Comprehensive Survey‘‘, International Journal of Computer Science and Engineering, Vol. 2, No. 6. Pp 2117 – 2123. 2010.
5. Vijayakumar, K: ‘‘Optimal Location of FACTS Devices for Congestion Management in Deregulated Power Systems’’, International Journal of Computer Applications, Vol. 16, No. 6. Pp 29 – 37. 2011.
6. Murali, D., Rajaram, M., amdReka, N: ‘‘Comparison of FACRS Devices for Power System Stability Enhancement’’, International Journal of Computer Applications, Vol. 8, No. 2010.
7. Rahul, S., and Manish, K: ‘‘A Review of Enhancement of Transient Stability by FACTS Devices’’, International Journal of Emerging Technologies in Science and Engineering, Vol. 5, No. 3. Pp 72 – 76. 2012.

8. Sowjanya, S. and Srinivasarao, J: ‘‘Design of FACTS Devices for the Improvement of Power System Stability using Mathematical Matching Controller’’, IOSR Journal of Electrical and Electronics Engineering, Vol. 1, Issue 3. Pp 7 – 11. 2012.

9. Ravi Kumar, S.V., and Siva Nagaraju, S: ‘‘Transient Stability Improvement using UPFC and SVC’’, ARPN Journal of Engineering and Applied Sciences, Vol. 2, No. 3. Pp 38 – 45. 2007.

10. Noroozian, M. and Anderson, G: ‘‘Power Flow Control by using Controllable Series Components’’, IEEE Transaction on Power Delivery, Vol. 8, No. 3. Pp 1420 -1429. 1993.

11. Adepoju, G.A: ‘‘Dynamic Stability Analysis of Electrical Power Systems Incorporating Flexible Alternating Current Transmission System (FACTS) Controllers’’, An unpublished Ph. D. Thesis, Ladoke Akintola University of Technology. 2010.

12. Bada, A.S.A: ‘‘Transmission Evacuation and Constraints’’, National Power Sector Retreat, January 20th – 21st, 2012.

13. Ibe, A.O., and Okedu, E.K: ‘‘A Critical Review of Grid Operations in Nigeria’’, The Pacific Journal of Science and Technology, Vol. 10, No. 2. Pp 486 – 490. 2009.

14. Sule, A.H: ‘‘Major Factors Affecting Electricity Generation, Transmission and Distribution in Nigeria’’, International Journal of Engineering and Mathematical Intelligence, Vol. 1, No. 1. Pp 159 – 164. 2010.

15. Onohaebi, O. S: ‘‘Power Transmission Constraints and Fault Analysis in the Nigerian Power System’’, Journal of Engineering and Applied Sciences, Vol. 2, No. 8. Pp 1314 – 1325. 2007.

16. Okafor, E.N., and Ezeh, G.N: ‘‘Outages in Nigeria Electric Power System: A Review’’, Journal of Economics and Engineering, Pp. 65 – 69. 2010.

17. Nwohu, M.N: ‘‘Optimal Location of Unified Power Flow Controller (UPFC) in Nigerian Grid System using Modified Sensitivity Analysis’’, Continental Journal of Engineering Sciences, Vol. 5, No. 2. Pp 20 -30. 2010.

18. Adepoju, G.A., Komolafe, O.A., and Aborisade, D.O: ‘‘Power Flow Analysis of the Nigerian Transmission System Incorporating FACTS Controllers’’, International Journal of Applied Sciences and Technology, Vol. 1, No. 5. Pp 186 -200. 2011.

19. Ambafi, J.G., Nwohu, M.N., Ohize, H.O., and Tola, O.J: ‘‘Performance Evaluation of PSS and STATCOM on Oscillation Damping of North-Central Power Network of Nigerian Grid System’’, International Journal of Engineering and Technology, Vol. 2, No. 2. Pp. 209 – 219. 2012.

20. Olalekan, D: ‘‘Optimization of Power Flow on Power Grid Using Unified Power Flow Controller (UPFC)’’, The Electrical and Electronics Engineers, Vol. 2, No. 2. Pp 24 – 27. 2012.