Middle-East Journal of Scientific Research 20 (8): 929-933, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.20.08.114003

Prospects of the Applying of UPFC in Modern Distribution Network

Pankaj Kumar, A. Rahul and S. Subha

Bharath University, Chennai, India

Abstract: The fault in the distribution network will cause voltage sags, three-phase imbalance and frequency fluctuations, seriously, forced to exit the system, increasing the instability of power and voltage in the distribution system. To solve many problems caused by the access of large-scale distributed wind power, to improve the penetration of wind power, to promote the development of wind power, to ease the environmental and economic issues that aroused by traditionally centralized power generation and to increase the quality and reliability of power supply. UPFC (Unified power flow controller, UPFC) is the most powerful FACTS controllers, it is well known to change the system parameters quickly and regulate the system voltage magnitude and phase angle so that it can control the system voltage and power flow. Taking the unified power flow controller as an example, this paper states the applying foreground of flexibility AC transmission system technology in distribution system. It proposes the idea that integrating the energy storage system into the DC bus of the unified power flow controller, The voltage regulation feature of UPFC to compensate for voltage asymmetry and fluctuations of distribution system voltage; the use of power flow regulation of UPFC can ensure DG working normally, even if the system is in failure to enhance the power system transmission capacity, when there exists the active shortage in the system, it need to provide active support to the static regulation of the system voltage and power flow for UPFC.

Key words: Increasing the instability · Large-scale distributed · Traditionally centralized · Applying foreground of flexibility

INTRODUCTION

In recent years, more and more distributed wind power generation system is in place access to distribution networks around the world. Wind power access, so that the power transmission system changes gradually from the traditional one-way flow to the two-way flow, causing the short-circuit current of the system increasing and the power transmission blocked; the uncertainty of the output of wind power makes the power distribution system fluctuate; fast and frequent changes of wind power in the size and trends make the node voltage of distribution system voltage keep fluctuating, even deviating its limits [1-5]. In addition, the fault in the distribution network will cause voltage sags, three-phase imbalance and frequency fluctuations, seriously, the wind turbines will be forced to exit the system, increasing the instability of power and voltage in the distribution system [6-9].

The development of large-scale distributed wind power generation, the increase of power quality and reliability requirements, demand a sufficiently flexible and smart modern distribution system with enough transmissioncapacity. However, due to economic constraints, theconstruction of a large and complex distribution network isbehind the booming construction of distributed powergeneration system, which is represented by the wind power [10-16].

Flexible AC Transmission Systems (FACTS) technologyhas been well known as its successful application in the powertransmission network. Applying the FACTS technology into the distribution network forms the distribution FACTS technology FACDS (flexible ac distribution systems), which is expected to build a flexible and controllable modern distribution network on the basis of the traditional network, to solve many problems caused by the access of

Corresponding Author: Pankaj Kumar, Bharath University, Chennai, India.

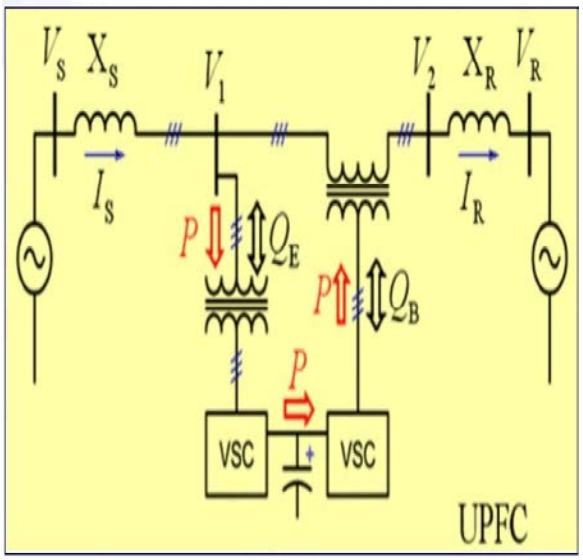

Fig. 2.0: Circuit Diagram of UPFC

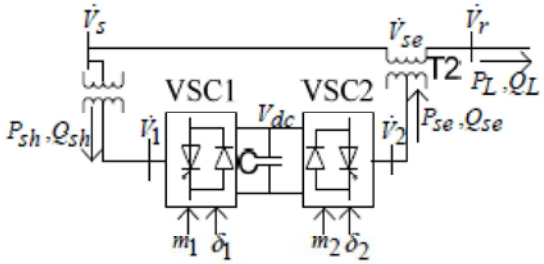

Fig. 2.2: Simplified schematic of UPFC

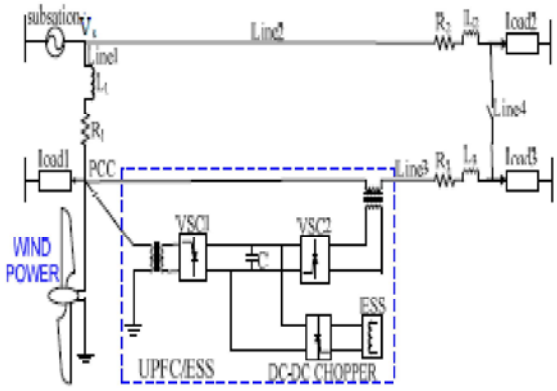

Fig. 2.3: Schematic of energy storage based UPFC accessing distribution system with wind power

large-scale distributed wind power [17], to improve the penetration of wind power, to promote the development of wind power, to ease the environmental and economic issues that aroused by traditionally centralized power generation and to increase the quality and reliability of power supply.

UPFC (Unified power flow controller, UPFC) is the most powerful FACTS controllers, it is well known to change the system parameters quickly and regulate the system voltage magnitude and phase angle so that it can control the system voltage and power flow. This paper will take it as a representative to explain the new mission given by the modern distribution network [18].

2.UPFC

Description of Circuit Diagram: The UPFC combines together the features of two FACTS devices: the Static Synchronous Compensator (STATCOM) and the Static Synchronous Series Compensator (SSSC). The DC terminals of the two underlying VSCsare now coupled and this creates a path for active power exchange between the converters [19]. Hence, the active power supplied to the line by the series converter, can now be supplied by the shunt converterTherefore, a fundamentally different range of control options is available compared to STATCOM or SSSC. The UPFC can be used to control the flow of active and reactive power through the line and to control the amount of reactive power supplied to the line at the point of installation.

Working Principle of Upfc in the Modern Distribution Network: The working principle of conventional UPFC, it consists of two back-to-back converter VSC1 (voltage source converter), VSC2 are coupled through the DC capacitor C, VSC1 is paralleled into system bus through the coupling transformer T1, VSC2 is connected in series into system through coupling transformer T2. The AC side voltage of converter VSC1 is V1, converter VSC2 is V2. By changing the converter firing angle δ1 , δ2 and the modulation ratio m1 [20], m2, VSC1, VSC2 injected reactive power Qsh, Qse into the system respectively to regulate the transmitter and receiver side bus voltage of the system; VSC2 injected Vse to the system, its changes in amplitude and phase can reach the purpose of adjusting the system flow. The stability of DC capacitor voltage is a working prerequisite of UPFC system.

The UPFC in distribution network with wind power in order to regulate the voltage of distribution network and to reduce the loss of distribution lines.

The voltage regulation feature of UPFC to compensate for voltage asymmetry and fluctuations of distribution system voltage [21]; the use of power flow regulation of UPFC can ensure DG working normally, even if the system is in failure.

The Control Method of Switching System: Wind power can be rectified through the VSC1 of UPFC and then charging to the energy storage device ESS through the DC-DC chopper circuit directly, without additional rectifier circuit. ESS acts not only as the wind power energy storage devices, but also as the support for the UPFC power unit. However, the existing storage device is mostly the form of DC power, when the ESS-based support UPFC system is at different wind speeds, the power needs to flow between wind power, ESS and system, it acts as the wind power energy storage devices and at the same time needs to inhibit the active power fluctuations, transient stability, voltage fluctuations and frequency fluctuations in the system through power control, to compensate for the asymmetry of the system voltage, to improve the low-voltage through ability of the wind power when the system is in the failure, to enhance the power system transmission capacity, when there exists the active shortage in the system, it need to provide active support to the static regulation of the system voltage and power flow for UPFC.

For this, the DC chopper undertakes the tasks of realizing ESS through the active power exchange with the UPFC and the wind power system for four quadrants.

So much energy flow and multi-objectives controlled complex systems, we must consider the three parts coordination control of voltage source converter in both series and parallel sides of the UPFC and DC chopper, in order to achieve the comprehensive control principle of new UPFC based on the energy storage.

Power system itself is a multi-variable, strong nonlinear dynamic time-varying system, the UPFC system based on energy storage technology was added in order to further strengthen the non-linear and coupled, the whole controlled system is then changed into a multi-objective, multi-level and extremely complex and hybrid system with the combination of discrete and continuous.

Most of the control to the existing FACTS devices are to control the continuous variables and discrete variables separately, which will affect the control performance; there are also some design methods to take the system continuous variables and the switching logic of switches as a whole, such as subsystems and the corresponding switching strategies with both discrete and continuous state path, it has been applied successfully in the process of robot and vehicle speed adjustment control and achieved good control effect. Since the switching system can describe characteristics of the controlled object accurately and control the system stably and respond to control rapidly, in the recent years, some experts and scholars have tried to introduce the concepts and theories into the study of power systems and power electronics systems.

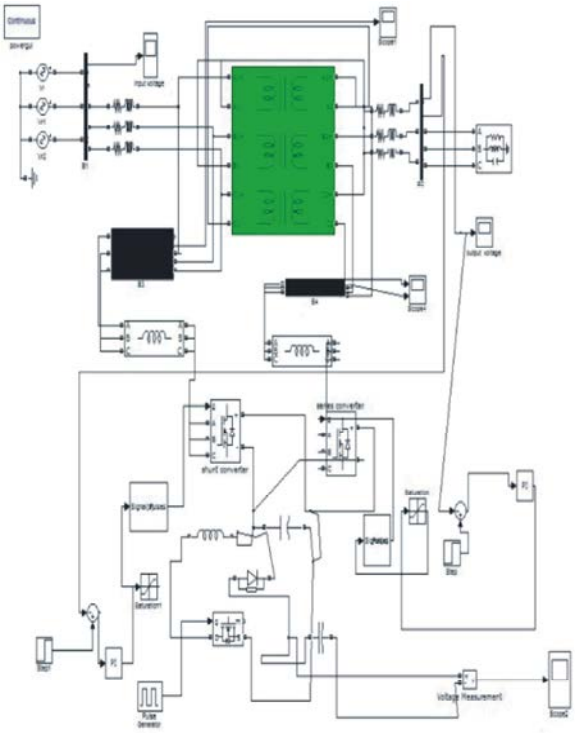

Fig. 4: Simulation Diagram

Simulation Diagram: Upfc simulation is based on the MATLAB Simulation model. As it is shown in the above simulation diagram it is clearly seen that the distribution of power in the power system is complicate and due to this complication many disturbance arises in the network, which affects the power distribution.

As the input is given in the power system and it distributed using three phase transformer, it can be seen in the scope that there are lots of noises and improper balance is present which cause frequency fluctuations, voltage problems.

So in order to rectify the problem upfc circuit is introduced, in this circuit there are two converters, one driver circuit, one dc link capacitor. The two converters in which one is rectifier which converts the ac to dc and aftere that, that converted dc power is fed to the dc link capacitor and the output of the dc link capacitor is fed to the second converter which is INVERTER converts the dc power to ac and then the rectified power is given as feedback power to be distributed.

Input Waveform

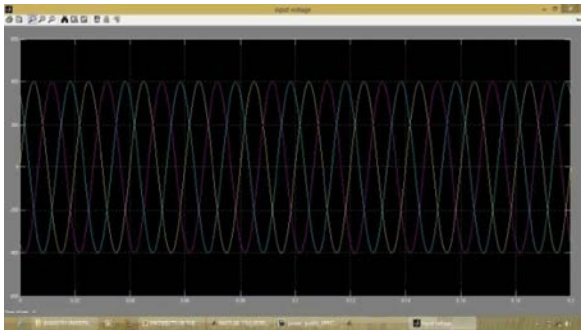

Fig. 4: 1Input Waveform

Distributed Power: This is the 3 phase input power which is given in the transmission lines for the distribution. Due to some losses occurs in the transmission linesthe output in the distribution network is distorted or we can say it is disturbed or there is some voltage sags or 3ph imbalancement occurs which cause improper flow or improper distribution of power in the distribution network.This is the distributed power which is distributed in the current distribution network. There are lots of noise present in the system in form of voltage sags, frequency fluctuation etc.

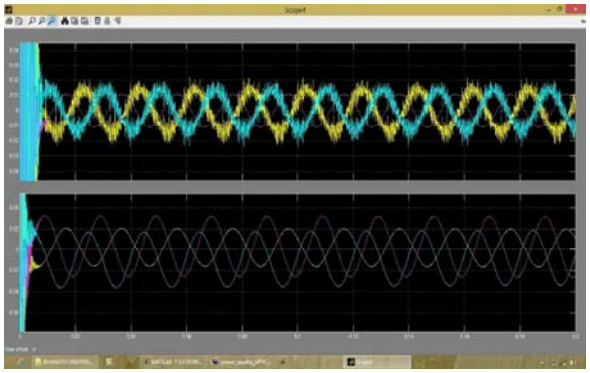

Fig. 4.2: Distributed Power

Output:

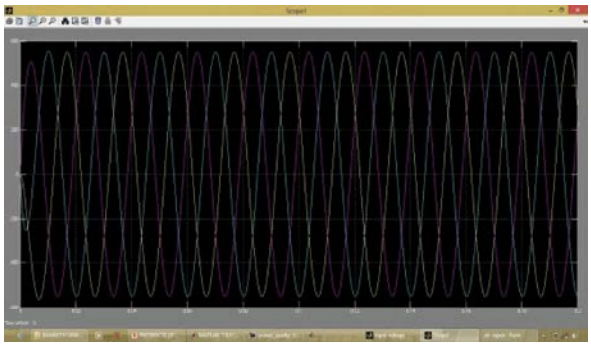

Fig. 4.3: Output Waveform

By the use of UPFC Fact controller it is clearly seen that all the problems in the distribution network is now rectified and there is continuous flow of power is available for distribution in which there is no frequency fluctuations, no voltage sag, no more noise is there. It is easily seen that there is pure energy is distributed over the transmission and distribution network.

CONCLUSION

This paper takes UPFC as an example; explain the effect of FACTS technology on the improvement of power quality in the modern distribution network with renewable energy represented by wind power. In this paper, the proposed topology model in which the ESS compatible with wind power will be access to the traditional UPFC DC bus is expected to be able to damp the oscillation of wind power and improve the capacity wind power through, under the premise of guaranteeing the power quality of distribution network.

REFERENCES

1. Taro Kondo, Jumpei Baba and Akihiko Yokoyama, 2008. Voltage Control of Distribution Network with a Large Penetration of Photovoltaic Generation Using FACTS Devices. Electrical Engineering in Japan, 165(3): 16-28.
2. Kechroud, A., J.M.A. Myrzik and W. Kling, 2007. Taking the Experience from Flexible AC Transmission Systems to Flexible AC Distribution Systems. Universities Power Engineering Conference, 2007. UPEC 2007. 42nd International, pp: 687-692.
3. Tomonobu Senjyu, Yuri Yonaha and Atsushi Yona, 2009. Stable Operation for Distributed Generators on Distribution System Using UPFC. Transmission & Distribution Conference & Exposition Asia and Pacific, pp: 1-4.
4. Mahmoud A. Sayed and Takaharu Takeshita, 2009. All Nodes Voltage Regulation and Line Loss Minimization in Loop Distribution Systems Using UPFC. Energy Conversion Congress and Exposition, 2009. ECCE 2009. IEEE, pp: 2719-2726.
5. Jayashri, R. and R.P. Kumudini Devi, 2009. Effect of Tuned Unified Power Flow Controller to Mitigate the Rotor Speed Instability of Fixed-speed Wind Turbines. Renewable Energy, 34(3): 591-596.

6. Dizdarevic, N., M. Majstrovic and G. Andersson, 2003. FACTS-based Reactive Power Compensation of Wind Energy Conversion System. Power Tech Conference Proceedings, 2003 IEEE Bologna, 8(2).
7. Tarafdar Hagh, M., A. Lafzi and A. Roshan Milani, 2008. Dynamic and Stability Improvement of a Wind Farm Connected to Grid Using UPFC. Industrial Technology, 2008. ICIT 2008. IEEE International Conference on, pp: 1-5.
8. Zhang, L., C. Shen, A. Arsoy and S. Atcitty, 2001. A Comparison of the Dynamic Performance of FACTS with Energy Storage to A Unified Power Flow Controller. IEEE., pp: 611-616.
9. Molina, M.G. and P.E. Mercado, 2004. Comparative Evaluation of Performance of a STATCOM and SSSC both Integrated with SMES for Controlling the Power System Frequency. 2004 IEEE/PES Transmission & Distribution Conference c1 Exposition: Latin America, pp: 535-541.
10. Wang, Q. and S.S. Choi, 2008. the Design of Battery Energy Storage System in a Unified Power-Flow Control Scheme. IEEE transactions on power Delivery, 23(2): 1015-1024.
11. Aihong Tang, Pingping Yin, Xianglian Xu, Shaorong Wang, Shijie Cheng, 2008. Performance of UPFC Integrated with SMES for Power Systems Controlling. ICEMS.
12. Domingo Biel, Rafael Ramos, Francesc Guinjoan, Juan Negroni, Carlos Meza, 2005. Sliding-mode Control Design of Parallel-Connected Switching Converters for Modular Transformerless DC-AC Step-up Conversion. ISCAS, pp: 3067-3070.
13. Masanori Sato, Atushi Kanda and Kazuo Ishii, 2007. A Switching Controller System for a Wheeled Mobile Robot. Journal of Bionic Engineering, 4(4).
14. Siu-Hong Wong, D.K.W. Cheng, Yim-Shu Lee and M.H.L. Chow, 2005. Design of Intelligent Switch System for In-vehicle Control Application. Power Electronics Specialists Conference, PESC, pp: 1865-1868.
15. Eseobar, G., A.J. Vander Schaft and R. Ortega, 1999. A Hamiltonian viewpoint in the modeling of switching power converters. Automatica, 35(3): 445-452.
16. Wang, Y., D. Cheng, C. Li and Y. Ge, 2003. Dissipative Hamiltonian Realization and Energy-Based L2-Disturbance Attenuation Control of Multimachine Power Systems. IEEE Trans. On Autom. Contr., 48(8): 1428-1433.
17. Jayalakshmi, V. and N.O. Gunasekar, 2013. Implementation of discrete PWM control scheme on Dynamic Voltage Restorer for the mitigation of voltage sag /swell, 2013 International Conference on Energy Efficient Technologies for Sustainability, ICEETS, pp: 1036-1040.
18. Uma Mageswaran, S. and N.O. Guna Sekhar, 2013. Reactive power contribution of multiple STATCOM using particle swarm optimization, International Journal of Engineering and Technology, 5(1): 122-126.
19. Arumugam, S. and S. Ramareddy, 2012. Simulation comparison of class D/ Class E inverter fed induction heating", Journal of Electrical Engineering, 12(2): 71-76.
20. Nagarajan, C. and M. Madheswaran, 2012. Experimental study and steady state stability analysis of CLL-T series parallel resonant converter with fuzzy controller using state space analysis, Iranian Journal of Electrical and Electronic Engineering, 8(3): 259-267.
21. Ramkumar Prabhu, M., V. Reji and A. Sivabalan, 2012. Improved radiation and bandwidth of triangular and star patch antenna, Research Journal of Applied Sciences, Engineering and Technology, 4(12): 1740-1748.