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Transient Stability Minimization for UPFC Controller Using ANN

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ABSTRACT

Renewable energy will become an important part of power generation. The problem of voltage stability has become a major disquiet in power system control operation. Seashore power generation combined with offshore wind turbine generators will become a new method for large electric energy production in the future. Here the offshore wind farm and seashore wave farm are integrated to produce large electricity and is fed to an onshore power grid through an UPFC. The UPFC is designed using ANN controller to simultaneously achieve the power fluctuation mitigation and dynamic stability improvement. Soft computing method of ANN is used to predict the power flow problems and voltage stability. The ANN controller is trained by using Hybrid Learning Algorithm. The simulation results shows that the proposed system can effectively achieve the stability improvement.

Keywords- Offshore wind farm(OWF), Seashore wave farm(SWF), Unified power flow controller(UPFC)

I. INTRODUCTION

Renewable energy is energy that is comes from natural processes that are continuously replenished. This energy cannot exhaust and is constantly renewed. The use of renewable energy has many benefits, including a reduction in green house gas emissions, the diversification of energy provisions and a reduced dependency on fossil fuels. Electricity generation from renewable sources has become the second major source of electricity worldwide.Wind energy is the kinetic energy allied with movement of large masses of air due to uneven heating of atmosphere by sun.Wind energy above the marine surface and wave energy can be simultaneously used to produce large electric power with several challenges including elimination of power fluctuations, securing power quality and so on. An offshore wind farm and seashore wave farm are combined effectively for large electricity production in the whole world in near future.The integrated OWF and SWF are connected to a grid through UPFC[1]. A superconducting magnetic energy storage system is used to achieve power flow control and enhancement of stability of a hybrid wind and marine current farm fed to a power grid in [2]. In [3] the transient stability can be improved by using ANN based UPFC alsoin near future. The integrated OWF and SWF are connected to a grid through UPFC [1]. A superconducting magnetic energy storage system is used to achieve power flow control and enhancement of stability of a hybrid wind and marine current farm fed to a power grid in [2]. In [3] the transient stability can be improved by using ANN based UPFC. Also this controller increases the critical clearing time of system. The ANN controller is proposed for SSSCto improve the transient stability and voltage profile of the system in [4]. The fuzzy PI controller and ANN controller are designed for function of UPFC. ANFIC controller provides better results than PI controller[5]. The ANN designed to preserve the maximum power output of wind turbine in [6]. The power flow over the transmission line can be controlled by using UPFC.

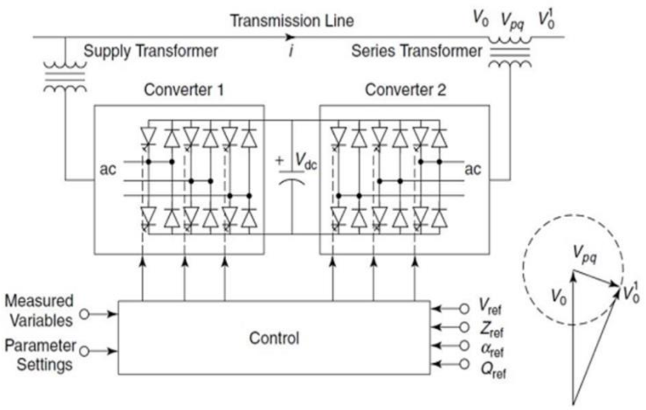

Fig.1. Basic UPFC model

The UPFC provides the powerful tool for real and reactive power control in double transmission line and also reduces the harmonics[6][10]. The proposed HVDC link is used to mitigate the power fluctuations and reduces the reactive power injections at Power grid. Voltage deviations are reduced at integration bus of OWF and SWF[7]. The ANN controller replaces the power system stabilizer for stability of power system[8]. ANN controller avoids the rule matching time of the fuzzy logic system[9]. An ANN has the advantages of computationally efficient, learning ability, reliable and speed of operation. It is very superior to conventional PI controller. In this paper the proposed UPFC joined with ANN controller is used to compensate the injected reactive power and mitigate the voltage fluctuations in an integrated offshore wind farm and seashore wave farm. The paper is summarized as follows. The configuration of system is discussed in section II. The UPFC based ANN controller is given in section III. Simulation results are discussed in section IV. The conclusion of this paper is drawn in section V.

II. SYSTEM CONFIGURATION

The configuration consists of integration of grid connected offshore wind farm and seashore wave farm through UPFC based ANN controller. This is shown in figure 1. The characteristics of studied offshore wind farm and seashore wave farm are simulated by 1.5 MW squirrel cage induction generator. The UPFC based ANN controller is proposed. The sugeno type fuzzy inference system is used in proposed ANN controller.

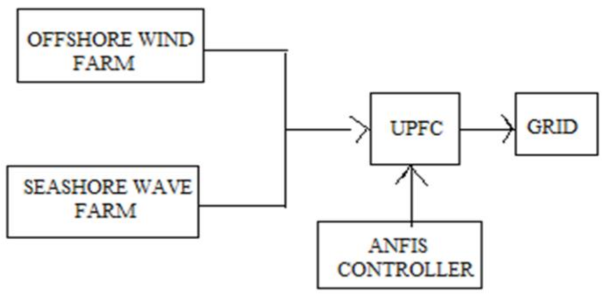

Fig.2. Integration of OWF and SWF connected to a grid through UPFC.

A. Offshore wind farm

Offshore wind power refers to the installation of wind farms located in the water. Offshore wind power reduces the green house gases by displacing fossil fuel power generation and also it meets the renewable electricity standards. There are no obstacles to distort the flow of wind.

B. Seashore wave farm

A wave farm is the set of machines located in the same area. Seashore wave farms are located in the either offshore or near shore areas. The electric energy can be produced from wave energy above the ocean. Highly usable power can be available in shore areas. The main advantage of SWF is high reliable and easily predictable.

C. UPFC model

The UPFC is the most adaptable FACTS devices. The UPFC consists of static compensator(STATCOM) andstatic synchronous series compensator(SSSC). The STATCOM refers the shunt part. The SSSC refers to the Series part of UPFC. Both are connected by common dc link capacitor. This device can independently control the both real and reactive power. The converter one is inserted in shunt with the line through shunt transformer. The converter two is connected in series with the line through series transformer. UPFC handles the dynamic system disturbances very effectively. This provides the functional flexibility. The Fig 2 shows the basic UPFC model.

D. ANN controller

It is the combination of neural networks and fuzzy inference system. It has potential to confine the advantages of both in single frame. In this method existing rules are tuned with learning algorithm based on a set of training data. Here sugeno fuzzy if-then rules are used. ANN does not have synaptic weights. The rules are constructed by the knowledge of experts. It is also called universal estimator. It has advantages of balancing, optimization and learning ability. The figure 3 shows the basic ANN structureThe error and correction are given to ANN to train the data. The error rate is used as the output data. The hybrid learning algorithm is used to testing the trained data. The ANN is used to control the UPFC.

III. DAMPING CONTROLLER FOR UPFC USING ANN

A. Hybrid learning algorithm

ANN uses hybrid learning algorithm to tune the parameters of sugeno type fuzzy inference system. The fuzzy inference system tracks the given input and output data for computing the membership function parameters. The algorithm uses the combination of least squares and back propagation gradient descent methods to model a training data set. ANN also evaluates models using a data set to test of training data. The hybrid learning rule comes into following two modes

i) Batch learning (offline)

ii) Pattern learning(online)

The speed of the learning process can be increased by using hybrid learning algorithm.

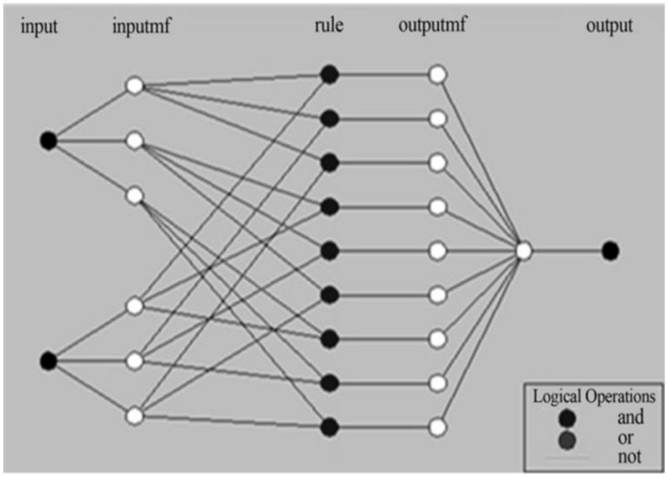

Fig.3.: Structure of ANN controller

ANN based controller

In this model, two ANN controllers have been designed. The performance of UPFC system was tested under various load conditions. The ANN Toolbox in the MATLAB is used for simulation of proposed method. Reference signal is generated by ANN controller. It is converted into pulse signal. Then it is given to the series and shunt inverter.

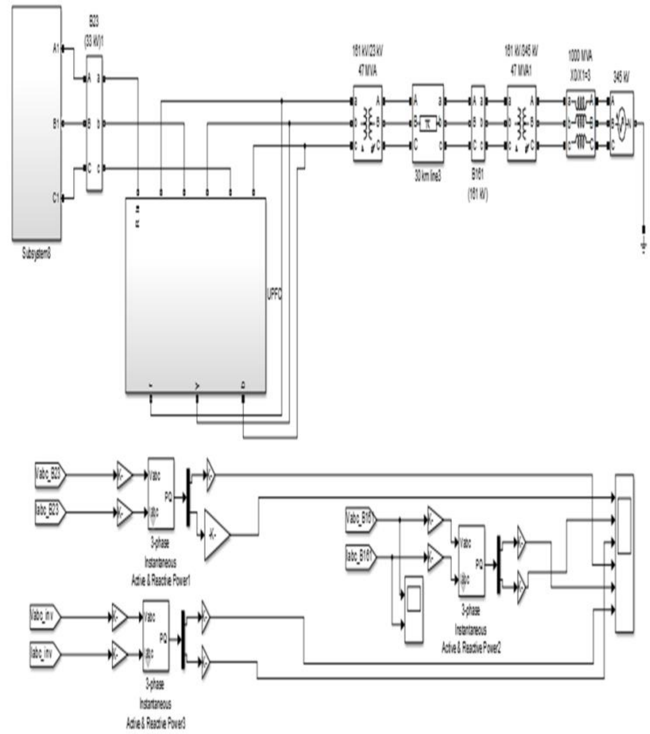

Fig.4: Integrated OWF and SWF fed to a grid through UPFC.

The figure 5 shows the voltage generated by integrated circuit without UPFC. At normal conditions the voltage is maintained at 0.9 p.u. The transition time of fault is set as 2-2.5 sec. During this fault conditions the voltage is decreased to 0.7 p.u. After this disturbance again the voltage is increased.

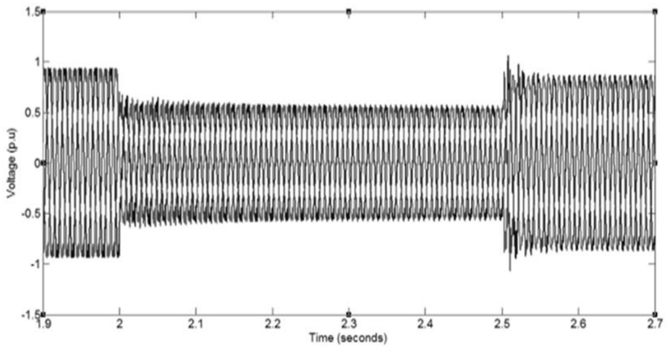

Fig.5: Voltage level without UPFC

The figure 6 shows the voltage generated by integrated circuit with UPFC. Under normal conditions the voltage is maintained at 1.0 p.u. with UPFC device. During disturbances the voltage is maintained at 0.9 p.u. This shows the UPFC device provides the better stability and controlled voltage under any disturbance conditions.

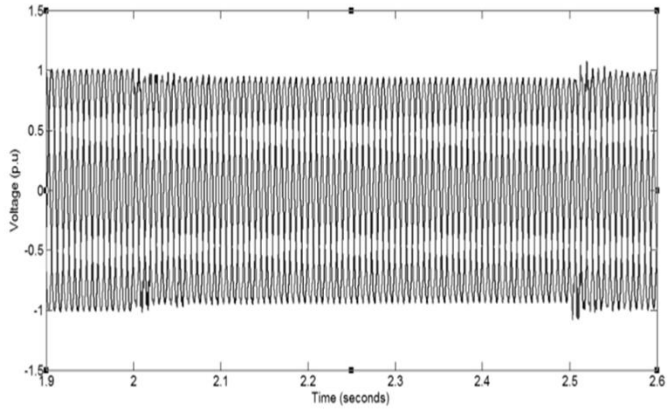

Fig.6: Voltage level with UPFC

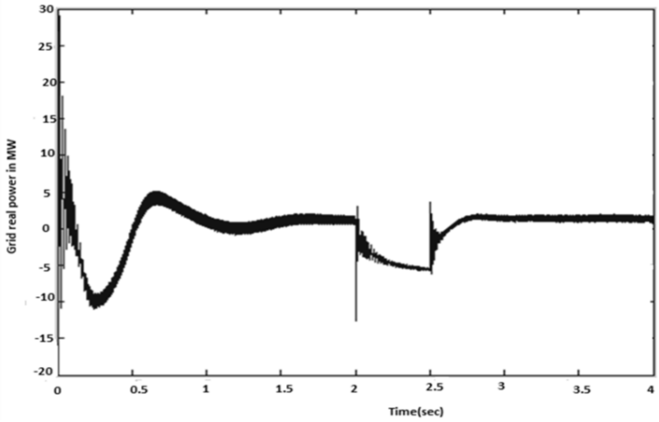

Fig.7: Grid real power with PI controller

The figure 7 shows the grid real power using UPFC with PI controller. Initially, oscillations are produced with high peak values. After 1.4 sec the real power reaches its steady state. The figure 8 shows the grid reactive power. Initially, high peak oscillations are produced in grid reactive power. After 1.4 sec it reaches steady state.

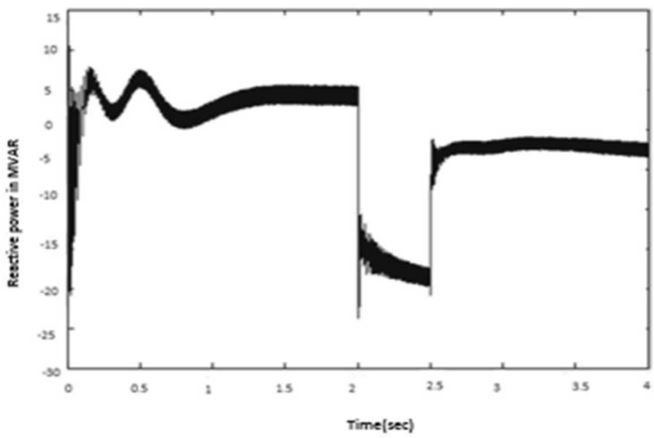

Fig.8: Grid reactive power with PI controller

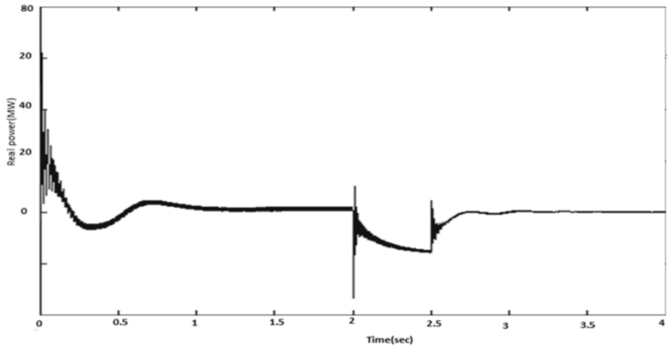

Fig.9: Grid real power with ANN controller

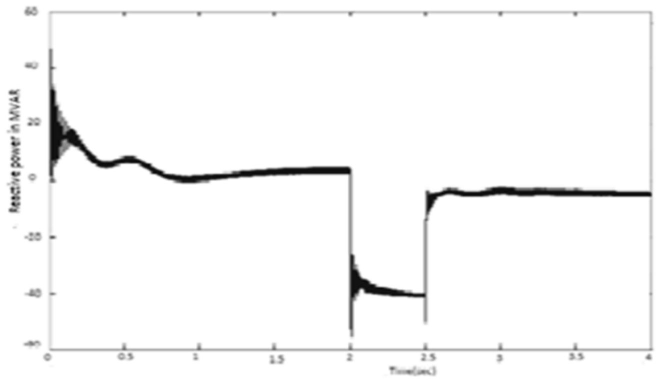

Fig.10: Grid reactive power with ANN controller

The figure 9 shows the grid real power by using UPFC based ANN controller. At first high peak oscillations are produced in real power fed to the grid. After 0.8 sec the grid real power reaches the steady state. The figure 10 shows the grid reactive power by using UPFC based ANN controller. It reaches steady state at 0.9 sec after the initial oscillations.During fault period the real and reactive power flow to the grid with acceptable oscillations by using damping controller of UPFC. The system provides the better stability after clearance of fault 2.5 sec.

Table I: Comparison between voltage level with UPFC and Without UPFC

Device	Normal conditions (P.U)	Abnormal conditions(P.U)
Without device	0.9	0.7
With device	1	0.9

Table II: comparison between PI controller and ANN controller

Methodology	Settling time(sec)	
	Real power	Reactive power
PI controller	1.4	1.5
ANN controller	0.8	0.9

In UPFC based ANN controller both real and reactive power quickly reaches steady state compared to PIcontroller. The proposed system proved the UPFC maintains the grid voltage even under disturbance conditions.

IV. RESULTS AND DISCUSSION

The integration of OWF and SWF is given to the grid through UPFC is shown in Fig.4. the first subsystem consists of integration of SWF and OWF. Here squirrel cage induction generator is used in wind turbine. SCIG is simple and can run independently. Three phase fault occurs during disturbance conditions. The next block refers the three phase current measurement and voltage measurement block. The next block shows UPFC. It is connected to the grid. The voltage from integrated part is given to the grid through UPFC in order to achieve the controlled voltage under various disturbances. It also compensates the reactive power.

V. CONCLUSION

This paper has presented simultaneous stability improvement and power flow control of a grid connected hybrid system containing OWF and SWF using UPFC based ANN controller. The D-Q control theory has been employed for damping controller of UPFC. The ANN controller of UPFC is trained by using hybrid learning algorithm. The simulation results prove that the ANN controller provides better stability compared to conventional controller. As a future work, the support vector machine is used to achieve the voltage and power flow control in proposed hybrid system.

VI. REFERENCES

[1]. Li Wang, Hao-Wen and Cheng-Tai wu "Stabilityanalysis of an integrated offshore wind and seashore wave farm fed to a power grid using a unified powerflow controller", IEEE Trans. on Power System, vol.28,no.3, aug2013.

[2]. Li Wang, Shiang-Shong Chen "Dynamic stability enhancement and power flow control of a hybrid wind and marine-current farm using SMES", IEEE Trans on energy conversion, vol.24, no.3, sep.2009.

[3]. F.Taki, S.Abazari, G.R.ArabMarkadesh "Transient stability improvement using ANN controlled UPFC based on energy function", ICEE journal on may.2010.

[4]. Swasti R. Khuntia ,Sidhartha Panda "ANN approach for SSSC controller design for the improvement of transient stability performance", Elsevier Ltd. 2011.

[5]. B. Gopinath , Juvan Michael , Dr. S. Suresh Kumar " Modelling of UPFC using advanced control techniques", International Journal of Engineering Research & Technology, Vol. 1 Issue 10., Dec 2012.

[6]. DaliborPetkovic, ZarkoCojbasi ,VlastimirNikolic "Adaptive neuro-fuzzy maximal power extraction of wind turbine with continuously variable transmission" Elsevier Ltd,. 2013.

[7]. SubhashChanderSwamil, AnuragPandey "Real and Reactive Power Flow Analysis & Simulation with UPFC Connected to a Transmission Line" International Journal of Science and Research on april.2015.

[8]. PhanxuanLe,Nguyen Le Thai,Nguyen Le Minh Tri "Research methods for power system stability using ANN" American journal of electrical power and energy systems ., Nov,2014.

[9]. Nisha Rajan S, Akash Rajan, Binulal B. R "Input mapping and simulation analysis using Adaptive network based fuzzy inference system" International journal of engineering and advanced technology, Feb 2015.

[10]. SajjadGolshannavaz, FarrokhAmini and DaryoushNazarpour"Application of UPFC to Enhancing Oscillatory Response of Series-Compensated Wind Farm Integrations" IEEE transactions on smart grid,vol. 5,No 4.,Jul 2014.

[11]. Li Wang, Senior Member, Mi Sa-Nguyen Thi "Stability Enhancement of Large-Scale Integration of Wind, Solar, and Marine-Current Power Generation Fed to an SG-Based Power System Through an LCC-HVDC Link" IEEE transactions on sustainable energy, vol. 5, No 1., Jan 2014.

[12]. Li Wang, Shen- ronjan, Hao- wenli "Analysis of an integrated OWF and SWF fed to a power grid through a variable frequency transformer," IEEE conferences on power & energy society, 2011.

[13]. Li Wang, Shen-Ron Jan, Chao-Nan Li, Hao-Wen Li, Yi-HsuanHuang,Yi-Ting Chen, and Sheng-Wen Wang "Study of a Hybrid Offshore Wind and Seashore Wave Farm Connected to a Large Power Grid through a Flywheel Energy Storage System", Power and energy society general meeting, IEEE2011.