Efficient Controlling of Low Frequency Oscillation in IPFC Based Multimachine Power System with ANN

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Abstract – The rising of demand of power and difficulties of constructing a newly transmission network causes the power system to be complex and stressed. UPFC is the power electronic device which efficiently control over the active and reactive power. The proposed controller system in this work consists of Frequency oscillation damping controller and Interline Power Flow Controller (IPFC). The need of controller for suppressing oscillation using artificial neural networks Controller with ANN. Within an interconnected power system, the power flow over a tie-line should be maintained near a constant level under normal conditions. However, low frequency electromechanical oscillations may occur spontaneously under certain circumstances. When such oscillations occur, electric power can be transmitted back and forth over the tie-line. This work is focused on the development of intelligent control algorithms, and more specifically, IPFC based Multimachine Power System with ANN control to improve the damping of low frequency oscillations in electric power systems.

Indexed Terms – IPFC, Frequency Oscillation, ANN, UPFC.

I. INTRODUCTION

Modern bulk power systems cover large geographic areas, e.g. the European UCTE system and the North American systems, and have a large number of load buses and generators. Additionally, available generating plants are often not situated near load centers and power must consequently be transmitted over long distances. To meet the load and electric market demands, new lines should be added to the system, but due to environmental reasons, the installation of electric power transmission lines must often be restricted [1]. Hence, the utilities are forced to rely on already existing infra-structure instead of building new transmission lines. In order to maximize the efficiency of generation, transmission and distribution of electric power, the transmission networks are very often pushed to their physical limits, where outage of lines or other equipment could result in the rapid failure of the entire system. With such increasing stress on the existing transmission lines the use of Flexible AC Transmission Systems (FACTS) devices becomes an important and effective option [2].

FACTS technologies offer competitive solutions to today's power systems in terms of increased power flow transfer capability, enhancing continuous control over the voltage profile, improving system damping, minimizing losses, etc [2]. FACTS technology consists of high power electronics based equipment with its real-time operating control. There are two groups of FACTS controllers based on different technical approaches, both resulting in controllers able to solve transmission problems [3].

The power system may be thought of as a large, interconnected nonlinear system with many lightly damped electromechanical modes of oscillation [4]. If the damping of these modes becomes too small, or even positive, it can impose severe constraints on the system's operation. It is thus important to be able to determine the nature of those modes, find stability limits and in many cases use controls to prevent instability [5]. The poorly damped low frequency electromechanical oscillations occur due to inadequate damping torque in some generators, causing both local-mode oscillations (1 Hz to 2 Hz) and inter-area oscillations (0.1 Hz to 1 Hz) [6].

A conventional damping control design considers a single operating condition of the system [1]. In this kind of controller the feedback is fixed and amplifies the control error, which in turn determines the value of the input signal (controller output) to the system. The way in which the error is processed is the same for all operating conditions. In case of contingencies, changed operating conditions can cause poorly damped or even unstable oscillations since the controller parameters yielding satisfactory damping for one operating condition may no longer provide sufficient damping for another one. In order to address this issue, researchers, over the years, have proposed different approaches for adaptive control structures for PSSs as well as for FACTS devices [3].

II. OUR WORK

A. IPFC ANN

Low Frequency Oscillations (LFO) occur in power systems because of lack of the damping torque in order to dominance to power system disturbances as change in mechanical input power. In the recent past Power System

Stabilizer (PSS) was used to damp LFO. FACTs devices, such as Unified Power Flow Controller (IPFC), can control power flow and increase transient stability [7]. So IPFC may be used to damp LFO instead of PSS [8]. IPFC damps LFO through direct control of voltage and power. In this research the linearized model of synchronous machine (Heffron-Philips) connected to infinite bus (Single Machine-Infinite Bus: SMIB) with IPFC is used and also in order to damp LFO, adaptive ANN damping controller for IPFC is designed and simulated. Simulation is performed for various types of loads and for different disturbances. Simulation results demonstrate that the developed ANN damping controller would be more effective in damping electromechanical oscillations in comparison with the conventional lead-lag controller [1].

The Benefits of Flexible AC Transmission Systems (FACTs) usages to improve power systems stability are well known [9]. The growth of the demand for electrical energy leads to loading the transmission system near their limits. Thus, the occurrence of the LFO has increased. FACTs controllers has capability to control network conditions quickly and this feature of FACTs can be used to improve power system stability. The IPFC is a FACTS device that can be used to the LFO [3]. The primarily use of IPFC is to control the power flow in power systems. The IPFC consists of two voltage source converters (VSC) each of them has two control parameters namely me, δe, mb and δb. The IPFC used for power flow control, enhancement of transient stability, mitigation of system oscillations and voltage regulation [9]. A comprehensive and systematic approach for mathematical modeling of IPFC for steady-state and small signal (linearized) dynamic studies. The other modified linearized Heffron-Philips model of a power system installed with IPFC is presented in figure 2.1. For systems which are without power system stabilizer (PSS), excellent damping can be achieved via proper controller design for IPFC parameters. By designing a suitable IPFC controller, an effective damping can be achieved. It is usual that Heffron-Philips model is used in power system to study small signal stability. This model has been used for many years providing reliable results [10].

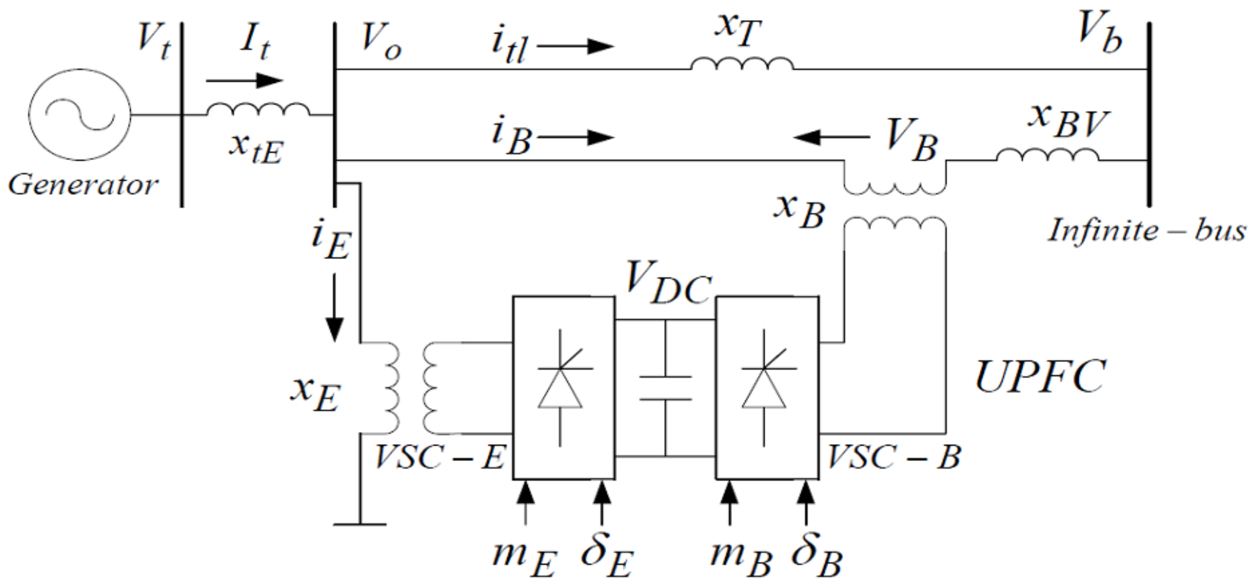

Figure 2.1 Heffron-Philips model of a power system installed with IPFC

A linearized model of the power system is used in dynamic studies of power system. In order to consider the effect of IPFC in damping of LFO, the dynamic model of the IPFC is employed [5]; in this model the resistance and transient of the transformers of the IPFC can be ignored illustrated in figure 2.2.

IPFC is one of the famous FACTs devices that is used to improve power system stability [4]. Fig.2.2 shows a multimachine - system with IPFC. It is assumed that the IPFC performance is based on pulse width modulation (PWM) converters [6]. In figure 2.3 shows the model of proposed system. The modeling has done in Matlab 11.2a.

B. Adaptive Artificial neural networks Controller Design

Before the ANN can be used to adapt the controller gains in real time, it is necessary to determine a proper set of values for the connection weights. The process of reaching the connection weights is normally carried out off-line and is usually referred to as the training process. In the training process, we first compile a set of training patterns and store these training patterns in the training set. Each training pattern comprises a set of input data and the corresponding output data. A training pattern set of training patterns, which cover a wide range of operating conditions, is finally used to train the desired ANN. It should be noted that we use two hidden layers. Main purpose of ANN is used for the reducing the error in the system, for that we are going to use training data method.

In this method, we have to give both input values and desired output value for estimating the weight values, in that initial value taken as a random value [10].

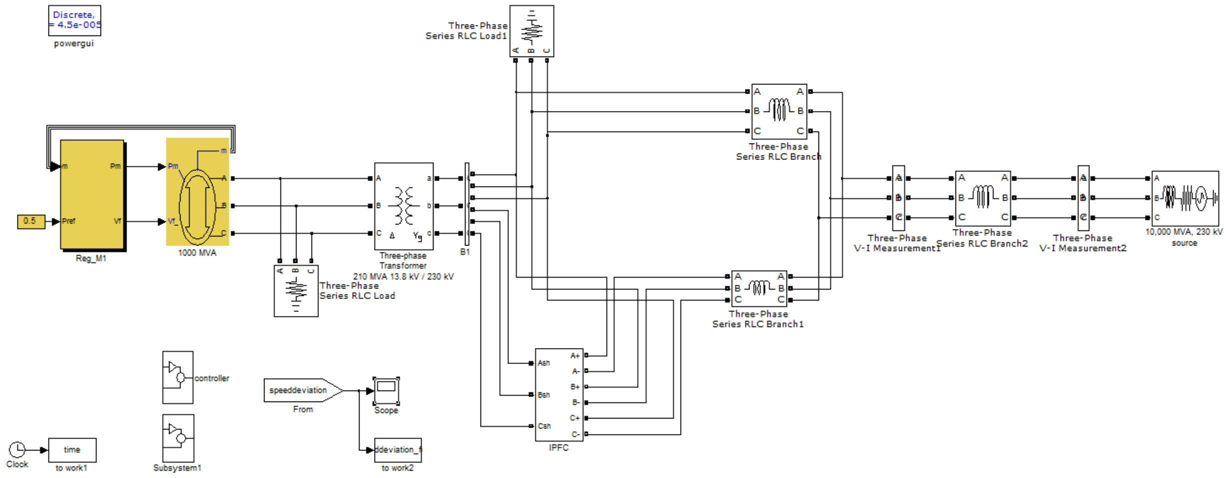

Figure 2.2 Proposed multimachine power system installed with an IPFC

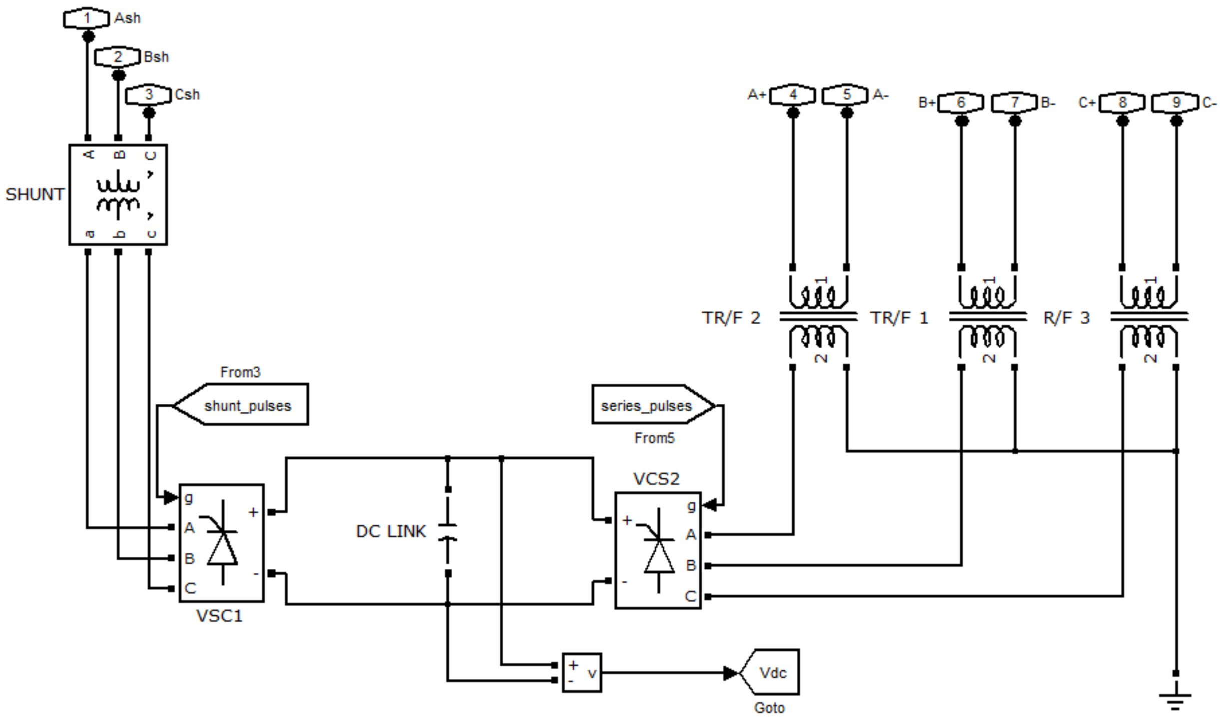

Figure 2.3 Proposed Multimachine Power Systems with IPFC and its Controllers.

III. SIMULATION RESULT

The software program to simulate the power system and the controller has been written in Matlab C in house and graphs are plotted using MATLAB software Simulink. Performance analysis with and without damping controller are shown in the following figures figure 3.1. And figure 3.2. The aim of the controller is the damping of the generator oscillations after the fault is cleared. For comparing, the generator is first fitted with conventional controller.

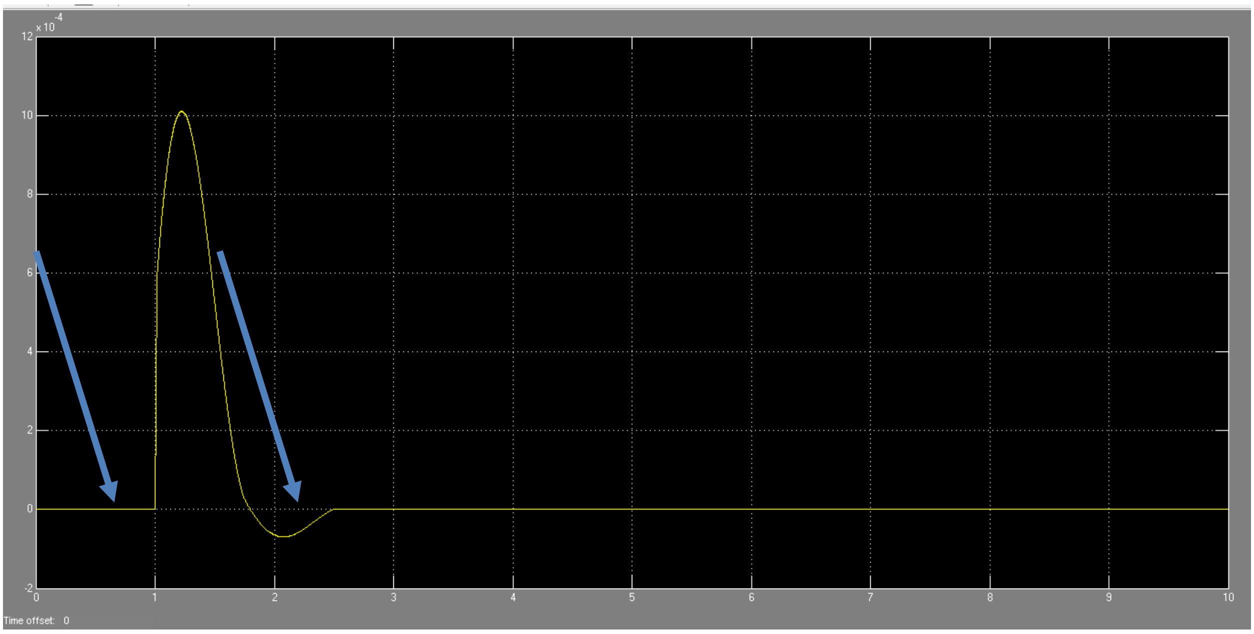

Figure 3.1 with ANN controller the setteling down of power oscillation is about 1 to 2.5 seconds only (i.e stabilising time is very low). This has very less amount of +ve & -ve sequence power oscillation damping (setteling down time is very low i.e, just 1.5 sec only).

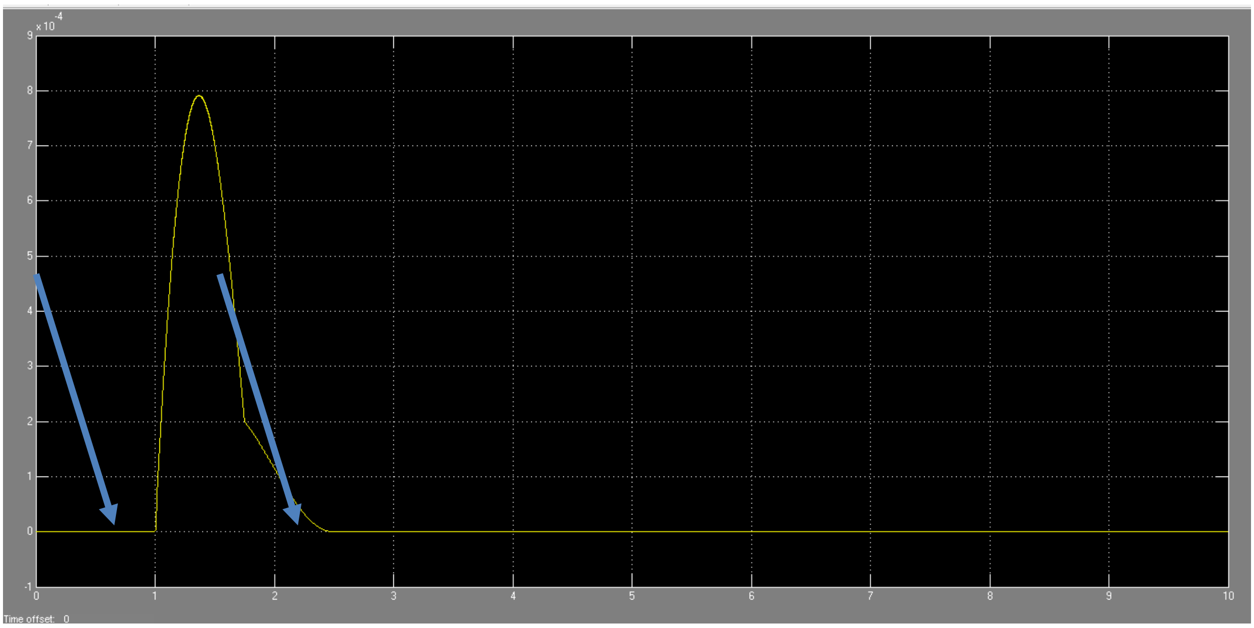

Figure 3.2 With ANN controller the setteling down of power oscillation is about 1 to 2.5 seconds only (i.e stabilising time is very low) .There isn't any -ve sequence power oscillation dampings (setteling down time is very low i.e, just 1.5 sec only)

IV. CONCLUSION

With regard to IPFC capability in transient stability improvement and damping LFO of power systems, an adaptive ANN damping controller for IPFC was presented in this paper. The controller was designed for a single machine infinite bus system. The simulation results for the proposed system including ANN damping controller are compared with simulation results for the base work [1] system. Comparison showed that the proposed adaptive ANN damping controller has good ability to reduce settling time and reduce amplitude of LFO. The solutions attained from the proposed method are optimum and nearer to the global solution. These proposed methods are also be suggested to get the solutions for the present power system networks. The better calculation productivity demonstrates that the proposed technique can be connected to extensive variety of power system for optimization issues. Based on the discussions and results, which are obtained in this research work, the intelligence based approaches can also be tested for various optimal power flow problems in power systems

REFERENCES

[1] M. Parimi, I. Elamvazuthi, A. V. P. Kumar and V. Cherian, "Fuzzy logic based control for IPFC for damping low frequency oscillations in multimachine power system," 2015 IEEE IAS Joint Industrial and Commercial Power Systems / Petroleum and Chemical Industry Conference (ICPSPCIC), Hyderabad, 2015, pp. 32-36.).

[2] N. G. Hingorani and L. Gyugyi, Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems: Wiley-Interscience, IEEE Press, A John Wiley & Sons, Inc., 2000.

[3] R. Narne and P. C. Panda, "Optimal coordinate control of PSS with series and shunt FACTS stabilizers for damping power oscillations," 2012 IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES), Bengaluru, 2012, pp. 1-6.)

[4] G. Nithya, D. Jananisri and M. Sowjanya, "Performance assessment of IPFC in power transmission systems," 2014 IEEE National Conference on Emerging Trends in New & Renewable Energy Sources and Energy Management (NCET NRES EM), Chennai, 2014, pp. 83-86.)

[5] P. S. A. Kumar, G. Radhakrishnan and V. Gopalakrishnan, "Stability improvement and power flow control of a grid connected offshore wind farm system using IPFC," 2014 IEEE International Conference on Computational Intelligence and Computing Research, Coimbatore, 2014, pp. 1-4.

[6] H. Rtibi, S. Elloumi and N. Benhadj Braiek, "Decentralized robust guaranteed cost control for multimachine power systems," Sciences and Techniques of Automatic Control and Computer Engineering (STA), 2013 14th International Conference on, Sousse, 2013, pp. 64-73.

[7] S. Sharma, S. Kulkarni, A. Maksud, S. R. Wagh and N. M. Singh, "Transient stability assessment and synchronization of multimachine power system using Kuramoto model," 2013 North American Power Symposium (NAPS), Manhattan, KS, 2013,

[8] X. P. Zhang, " Modelling of the interline power flow controller and generalized unified power flow controller in Newton power flow," IEE Proc- Generation Transm. Distrib., vol. 150, pp. 268-274, 2003

[9] A. M . Parimi, N. C. Sahoo, I. Elamvazuthi, N. Saad, N, “Transient Stability Enhancement and Power Flow Control in a Multi-Machine Power System Using Interline Power Flow Controller” IEEE International Conference on Energy, Automation and Signal, Dec. 2011

[10] G. Radhakrishnan, V. Gopalakrishnan, P. S. A. Kumar and M. M. Kumar, "Performance analysis and optimization of a multilevel power flow controller using Ann," 2014 IEEE International Conference on Computational Intelligence and Computing Research, Coimbatore, 2014, pp. 1-5.

[11] U. K. Soni, "Power quality improvement using PID based Reference Voltage Compensation with STATCOM," 2013 International Conference on Green Computing, Communication and Conservation of Energy (ICGCE), Chennai, 2013, pp. 397-403..

[12] Kevin M. Passino and Stephen Yurkovich, Fuzzy Control, Addison Wesley Longman, Menlo Park, CA, 1998.

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