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Hybrid Controller Based UPFC for Damping of Oscillations in Multi Machine Power Systems

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ABSTRACT

This paper explains about hybrid combination of a neural network with a UPFC and POD control strategy to damp the electro-mechanical oscillations in a multi machine power system. FACTS based integrated multi-machine power system consisting of 3 generators, 3 transformers, 9 buses, 4 loads and UPFC. Oscillations in power systems have to be taken a serious note of when the fault takes place in any part of the system; else this might lead to the instability mode and shutting down of the power system. UPFC based POD controllers can be used to suppress the oscillations upon the occurrence of a fault at the generator side or near the bus side In order to keep the advantages of the existing POD controller and to improve the UPFC-POD performance, a hybrid intelligent coordination based controller can be used ahead of a UPFC based POD controller to increase the system dynamical performance and to coordinate the UPFC-POD combination. The 3 phase to ground symmetrical fault is made to occur near the first generator. Simulations are performed without UPFC and with UPFC+POD+FUZZY and UPFC+POD+Neural Network controller.

Keywords : *UPFC, POD, Fuzzy logic, Controller, Oscillations, Damping, Stability, Neural Networks.*

1. INTRODUCTION

Nowadays, FACTS devices can be used to control the power flow and enhance system stability. They are playing an increasing and major role in the operation and control of power systems. The UPFC (Unified Power Flow Controller) is the most versatile and powerful FACTS device [1]. The parameters in the transmission line, i.e. line impedance, terminal voltages, and voltage angle can be controlled by UPFC. It is used for independent control of real and reactive power in transmission lines. Moreover, the UPFC can be used for voltage support and damping of electromechanical oscillations [2~4]. In this paper, a multi machine system with UPFC is simulated.

Damping of electromechanical oscillations between interconnected synchronous generators is necessary for secure system operation [5]. A well-designed FACTS controller can not only increase the transmission capability but also improve the power system stability. A series of approaches have been made in developing damping control strategy for FACTS devices. The researchers are mostly based on single machine system. However, FACTS devices are always installed in multi-machine systems. The coordination between FACTS controllers and other power system controllers is very important. Damping of electromechanical oscillations between interconnected machines in a integrated power system is always necessary for a secured system operation. A FACTS controller always increases the transmission capability and the stability. Researchers have developed a number of methods for damping of power system oscillations using FACTS devices. However, majority of them are confined to single machine infinite bus systems. Very few researchers have worked on multi machine control of FACTS systems. Of course, this yields satisfactory results [7]. But, excellent results can be obtained using the fuzzy logic concepts, neural network concepts & the genetic algorithms. This has been showed by few researchers in their papers [9], [10]. In this paper, we make a modest attempt to simulate neural logic control scheme with a UPFC for a FACTS power system to dampen the power system oscillations [8].

This paper focuses on the optimization of conventional power oscillation damping (POD) controllers and fuzzy logic controller and neural network coordination of them. By using fuzzy-coordination controller, the coordination objectives of the FACTS devices are quite well achieved. By using neural-coordination controller, the coordination objectives of the FACTS devices are quite best achieved.

2. SYSTEM MODEL

A three machine nine bus interconnected power system is simulated in this paper. The integrated multi-machine power system model consisting of 3 generators used for the simulation purposes is shown Fig.1.The generators 1, 2 and 3 are connected To buses 1, 5 and 8. UPFC is used for controlling & damping the power system oscillations in the integrated plant [10]. Three transformers T1 to T3 are also used in the integrated power system near the generator buses for the power transmission purposes, i.e., for stepping up & stepping down purposes.

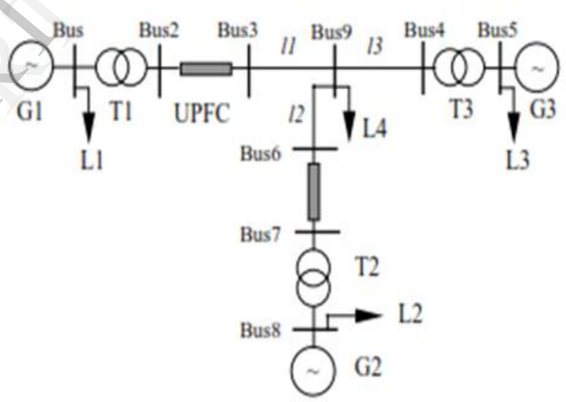

Fig 1.power system model

2.1. UPFC Model (UPFC Theory)

Basically, the UPFC have two voltage source inverters (VSI) sharing a common dc storage capacitor. It is connected to the system through two coupling transformers. One VSI is connected in shunt to the system via a shunt transformer. The other one is connected in series through a series transformer. The UPFC scheme is shown in Fig. 2.

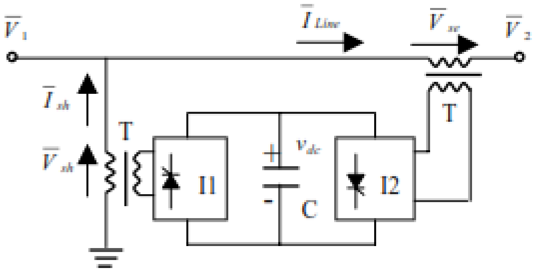

Fig 2.UPFC scheme

The UPFC has two operating modes. Shunt control mode can be two different ways

1) VAR control mode: the reference input is an inductive or capacitive Var request;

2) Automatic voltage control mode: the goal is to maintain the transmission line voltage at the connection point to a reference value.

By the control of series voltage, UPFC can be operated in four different ways :

1) Direct voltage injection mode: the reference inputs are directly the magnitude and phase angle of the series voltage;

2) Phase angle shifter emulation mode: the reference input is phase displacement between the sending end voltage and the receiving end voltage;

3) Line impedance emulation mode: the reference input is an impedance value to insert in series with the line impedance;

4) Automatic power flow control mode: the reference inputs are values of P and Q to maintain on the transmission line despite system changes. Generally, for damping of power system oscillations, UPFC will be operated in the direct voltage injection mode.

2.2. POD Controller

Commonly the POD controllers involve a transfer function consisting of an amplification link, a washout link and two lead-lag links [10]. A block diagram of the conventional POD controller is illustrated in Fig. 5. In this paper the active power of the transmission line is used as input signal.

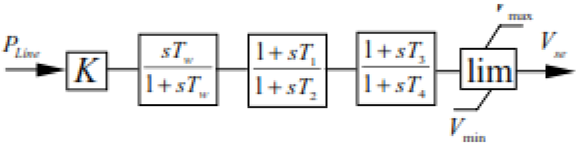

Fig 3. UPFC-POD controller

The UPFC-POD controller works effectively in single machine system. In order to improve the dynamic performance of a multi-machine system, the behavior of the controllers must be coordinated. Otherwise the power system will be deteriorated.

3.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 [16]. 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. The input are Δd and Δω, desired output is the function of f € { Δd b , Δd e , Δmb , Δm }.For each input having 20 membership functions and Two rule base is considered.

ANN architecture for a two input sugeno model with two rules is shown in figure2.in which we are using the XOR gate.

For the training data the error reducing method is the following steps are taken those are

1. Set the Learning Rate Parameter (ŋ) is greater than the one and error value E=0.
2. First Layer k =1.
3. Calculate the output value f i (n) = tansig (<W (μ(Δd)+μ(Δω))>)+ r ;for i=1,2,…20.
4. Calculate error E=E+1/2||f - f.
5. Weights are updated Wi+1 i = W(n)||i2 + ŋ (f-tansig(<Wi(μ(Δd)+μ(Δω))>) + r); for i=1,2..20.
6. Check error E is not zero, then take the layer value as k =k+1,
7. Repeat the above process until when the error E as zero.

From above process we get the desired output function, the output function

f =(1-e-(Wi (μ(Δd)+μ(Δω))+r) /(1+e-(Wii (μ(Δd)+μ(Δω))+r) . The range of output function is -1 to +1.

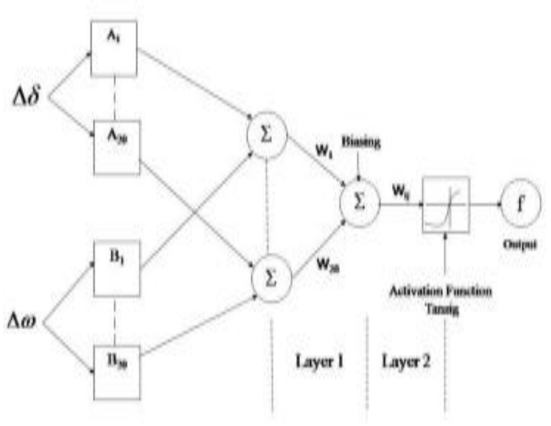

Fig 4.ANN architecture

4.SIMULATION RESULTS:

The simulation is run for 1 sec with & without the controller. we had taken a 3-generator nine bus system with 220 KV line and 100 MW generators. The 3 phase to ground symmetrical fault is made to occur near the first generator for 200 ms from the first cycle to the tenth cycle & is also simulated in the Simulink model. Due to the occurrence of the fault, the simulation results were observed with & without the controller. Fig 5 and Fig 6 shows the variation in load angle after applying a fault at generator 1 during 0.02 to 0.2sec .because of fault load will not come to stable condition. Fig 7and fig8 shows the variation in load angle after applying a fault at generator 1 during 0.02 to 0.2sec with upfc and fuzzy coordinated pod controller. Because of controller load angle will come to stable condition at 0.48 sec. Fig 9and fig10 shows the variation in load angle after applying a fault at generator 1 during 0.02 to 0.2sec with upfc and neural network coordinated pod controller. Because of controller load angle will come to stable condition at 0.44sec.

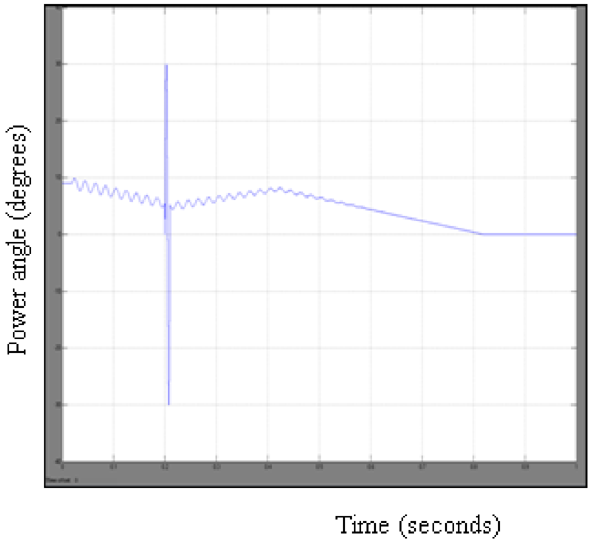

Fig 5. Load Angle At Gen1 Without UPFC

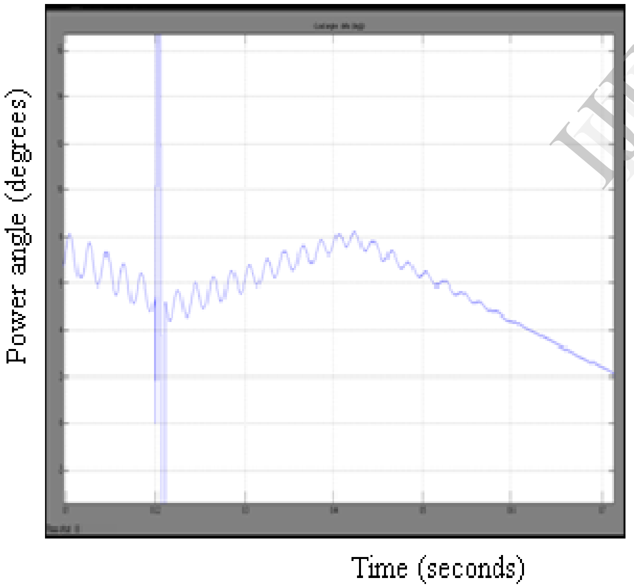

Fig 6. Load Angle At Gen1 Without UPFC (ZOOMED)

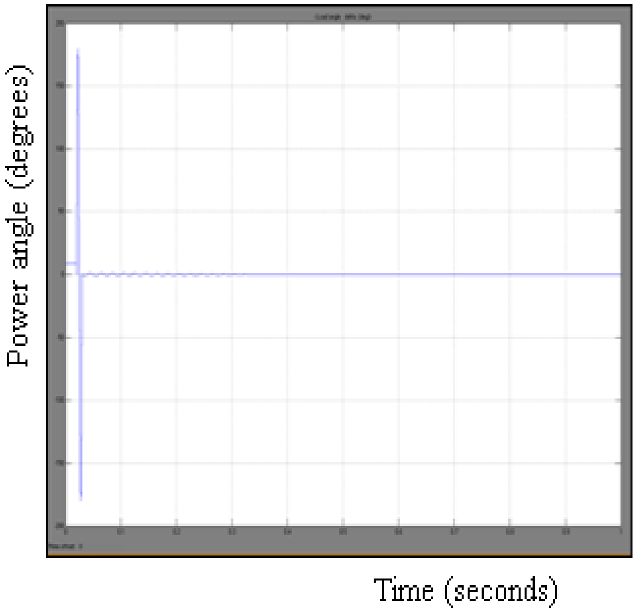

Fig 7. Load Angle At Gen1 With UPFC+ POD+FUZZY

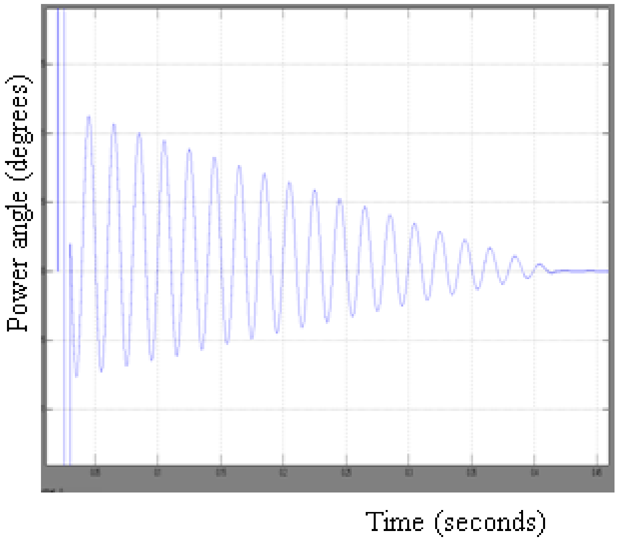

Fig 8. With UPFC+POD+FUZZY(ZOOMED)

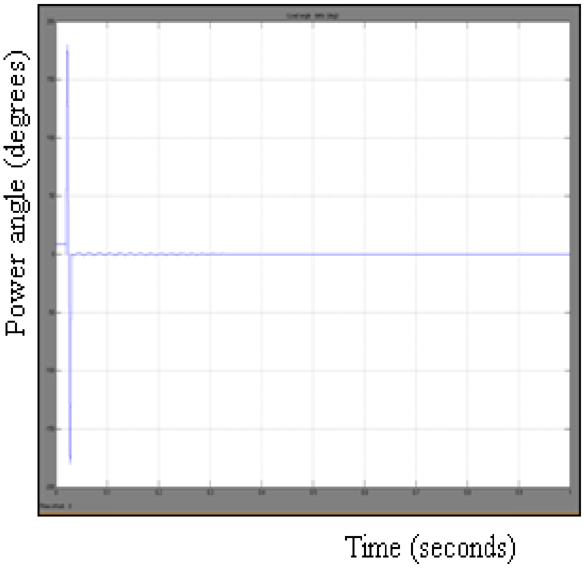

Fig9. Load angle With UPFC+POD+NEURAL NETWORK

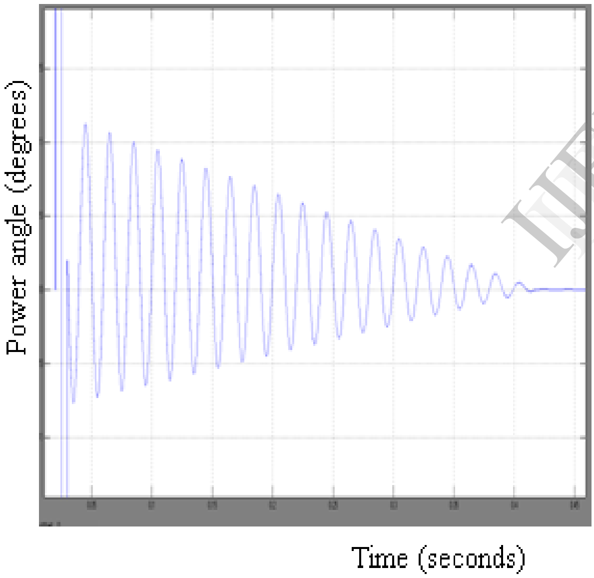

Fig 10.WITH UPFC+POD+NEURAL NETWORK (ZOOMED)

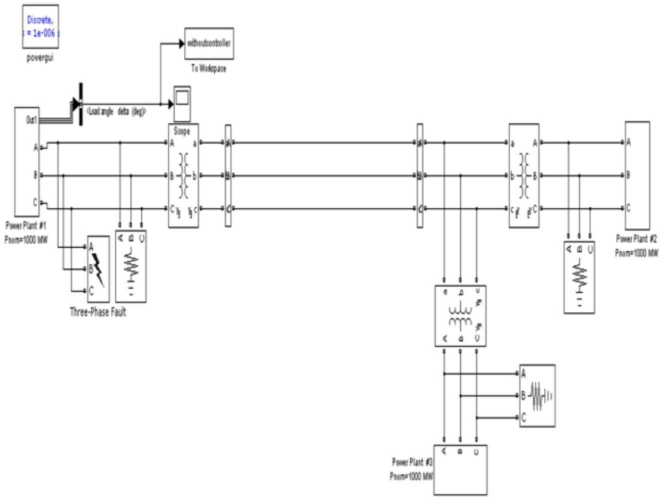

Fig11. Simulink model with out UPFC

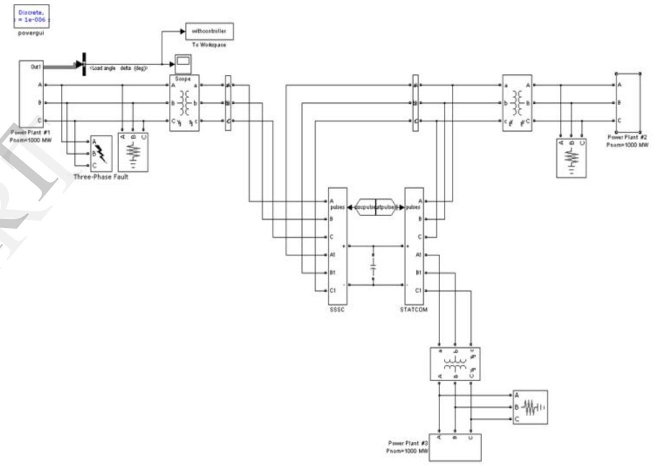

Fig12.Simulink model with UPFC

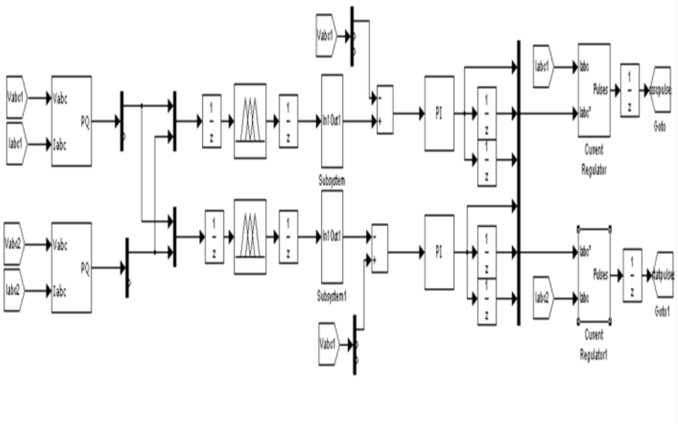

Fig13.Simulink model for UPFC Based controlling circuit

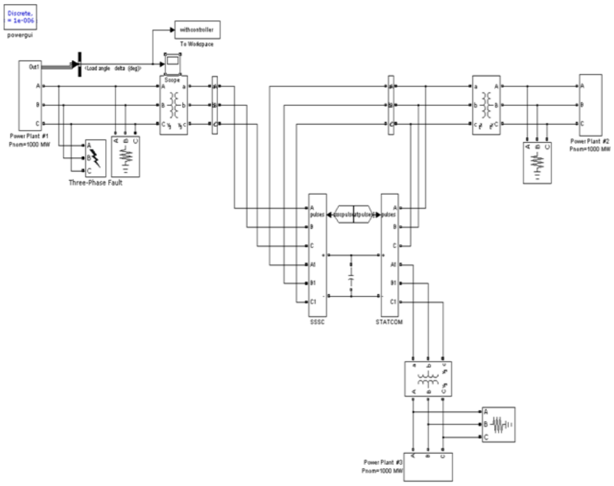

Fig14.Simulink model with Neural Network

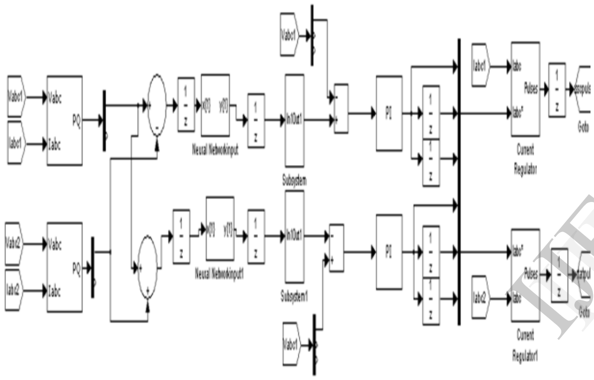

Fig15. Simulink model for Neural Network control

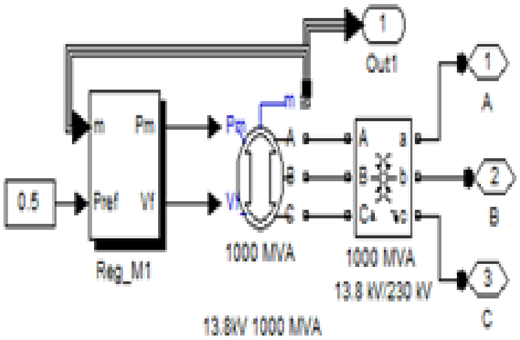

Fig16.Simulink model for Synchronous generator

It is clearly observed from the simulation results that with the developed controller, the dynamic performance of the power system is quite improved with the incorporation of the neural network coordination scheme. It is also observed that with the controller, the power angle characteristics curves exhibit very less overshoots & undershoots, the oscillations are also damped out in a lesser time. The response characteristics take less time to settle & reach the final steady state value.

5.CONCLUSION:

There are lot of ringing oscillations (overshoots undershoots) & the output takes a lot of time to stabilize, which can be observed from the simulation results. But, from the incorporation of the neural network incorporated POD based UPFC system in loop with the plant gave better results comparing with fuzzy based upfc thereby reducing the disturbances in the power angle and also the post fault settling time also got reduced a lot. The system stabilizes quickly, thus damping the Local mode oscillations and reducing the settling Time immediately after the occurrence of the fault.

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