Adaptive Neuro Fuzzy Controller Based Power System Stabilizer for Damping of Power Oscillation Control in Two Area Four Machine Power System

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ABSTRACT

Maximum power transfer and optimal power flow is desired which is affected by the inter area oscillation of low frequency .To avoid low frequency inter area power oscillations power system stabilizer is added to the automatic voltage regulators on the generators. Stabilizer provides the means to damp these low frequency power oscillations .Different types of stabilizers are available to damp power oscillations still a power system stabilizers can be developed to effectively damp low frequency power oscillations. Without increasing the system complexity these oscillations can be reduced with the help of developing power system stabilizer to damp the low frequency inter area power oscillations.

Adaptive Neuro Fuzzy Interface system (ANFIS) is designed to achieve fast and effective power oscillation damping in two area four machine power system. This work is implemented with MATLAB simulink 2012(b). Also comparative analysis of low frequency power oscillation damping of ANFIS controller based stabilizer and conventional PID power system stabilizer is presented in this paper. Comparison of results show that low frequency inter area power oscillation damping of ANFIS controller based stabilizer is much higher than PID power system stabilizer. Also damping time provided by ANFIS controller based power system stabilizer is 75% less in comparison to PID power system stabilizer .

KEYWORDS: *Keyword 1, Keyword 2, Keyword 3, Keyword 4, Keyword 5PID Controller, Power System Stabilizer, Adaptive Neuro Fuzzy Interface System Controller*

I. Introduction

System events when coupled with a poorly damped electric power system causes Inter area power oscillations. Large systems with group of generating lines which are connected by weak tie lines consists of oscillations . Group of generators on one side of tie lines oscillating against groups of generators on the other side consists of low frequency modes ranging from 0.1Hz to 0.8Hz.Sub-optimal power flow and ineffective operation of grid are caused by undesirable low frequency oscillations. Therefore it is important to stabilize these low frequency oscillations.

The dynamic stability of power systems can be increased by the help of power system stabilizer which damps out the low frequency oscillations. Due to non-linearity of power systems, exact mathematical model of system is difficult to obtain. Optimum damping to the system oscillations under wide variety in system conditions and parameters can be provided by fuzzy logic based PSS ,adaptive self tuning artificial neural network. More effective optimization technique should be utilized to take full advantage in simplifying the problems and its implementations [1-5].

This paper presents the effective and fast damping of inter area power oscillation and improved dynamic stability of interconnected power systems by designing of an ANFIS controller for damping low frequency power oscillations in two area four machine system. disturbances has received much attention.

A. *Four Machines Two Area Test System*

In MATLAB 2012(b) test system is available consisting of two (fully) symmetrical areas which are linked together by two tie line 230KV lines of

220Km length shown in figure 1. This test system was designed to study the low frequency electrochemical oscillations in large power systems.

Each area of test system consists of two identical round rotor generators rated 20KV/900MVA. The parameters of synchronous machines are same except for the inertia in area 1 is H=6.5s and inertia for area 2 is H=6.175s. Thermal plants having an identical speed regulator which has gain of 100

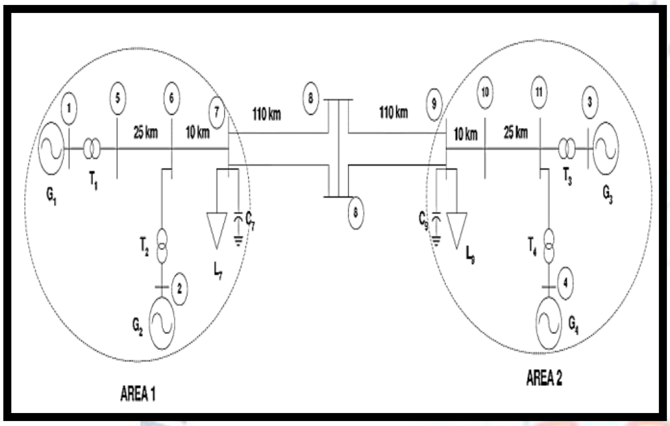

Fig. 1 Two Area Four-Machine power system for Stability Analysis

Simulation model used for study of the PID-PSS and proposed ANFIS controller based power system stabilizer (Hybrid-PSS) for Inter area power oscillation stability is shown in fig.2.

Also Fig.3. is internal structure of area-1 and fig.4. Shows the internal configuration of regulator and turbine which consists of PID power system stabilizer and ANFIS power system stabilizer.

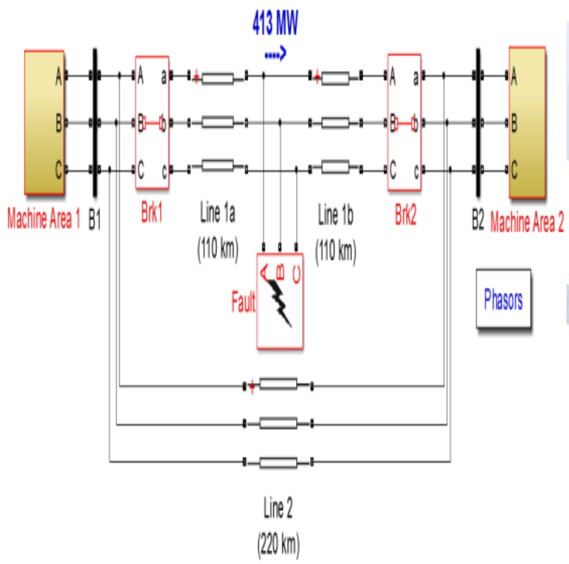

Fig. 2 simulation model implemented with PID-PSS and proposed ANFIS-PSS for Inter area power oscillation stability Analysis.

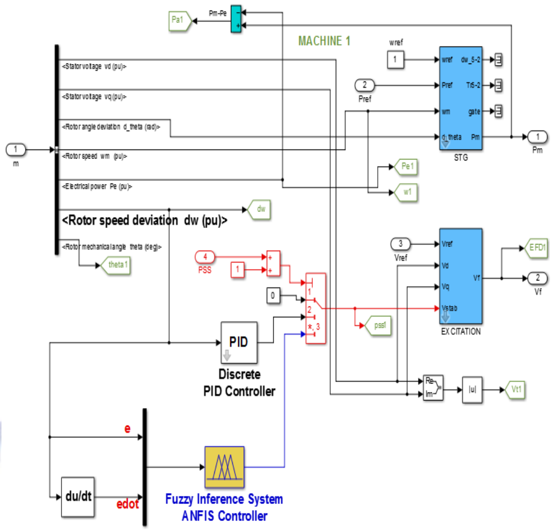

Fig.3 Area -1 (internal configuration)(subsystem)

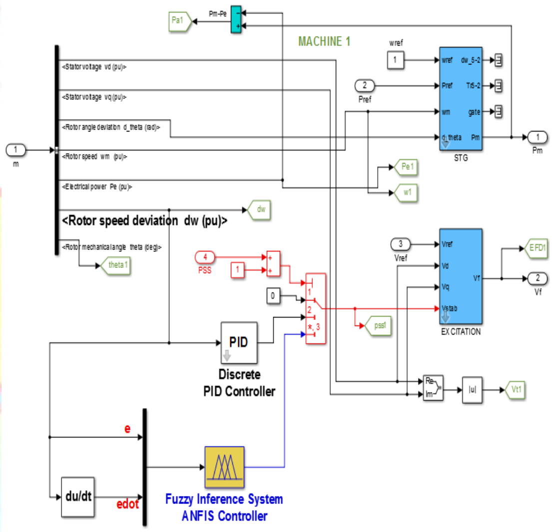

Fig.4 Internal configuration of turbine and regulator with PID-PSSand proposed Hybrid-PSS.

II. Proposed System

A. Proposed ANFIS Controller for Inter area Power Oscillator Damping

During the development of proposed ANFIS controller two input variables have been employed to provide robust performance against power oscillations. Variables, error (e) which is the rotor speed deviation (in pu) has been used as first input variable, while on the same time the rate of change of error signal ($\dot{e}$) has been taken as the second input variable for the designing of proposed controller.

Following steps have been employed for developing proposed ANFIS controller:

Step-1. Obtain the input and outputs of conventional PID controller.

To model required ANFIS controller we need to first analyze the deficiency of PI controller during generation of control signal terminal voltage V_f in response to the variation in rotor speed deviation. To analyze the controlled terminal voltage V_f values generated by PID controller, Fig. 5 shows the input plot of PID and fig .6. shows the out put plot of PID and for three phase to ground fault .

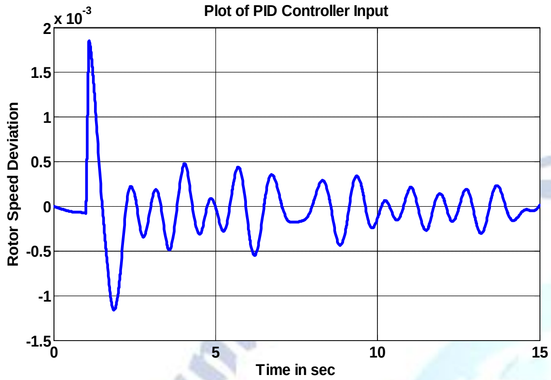

Fig. 5. PID Controller Input.

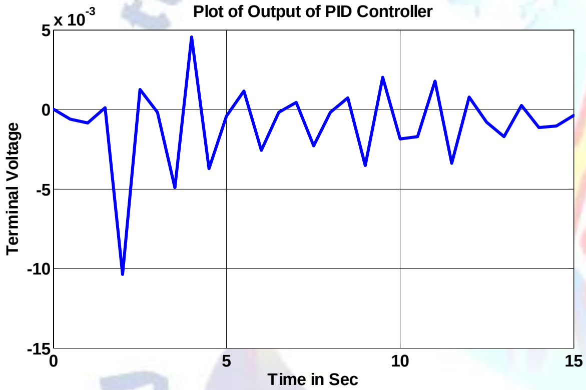

Fig. 6. PID Controller Output.

From the output response of PID controller shown in fig. 6, it is clearly observable that, there are a huge amount of fluctuations in controlled terminal voltage values generated by PID controller in response to the variation in rotor speed deviation.

Step-2. Make corrections on output of conventional PID controller, which will provide desired improved power quality (i.e. higher damping in power oscillation).

Step-3. Train the ANFIS for obtained same inputs as used for PID controller and corrected output data.

After designing of the proposed ANFIS controller using aforesaid steps; the membership functions designed for the two inputs error (e) and change rate of error ($\dot{e}$)are shown in Fig.7 and Fig.8,

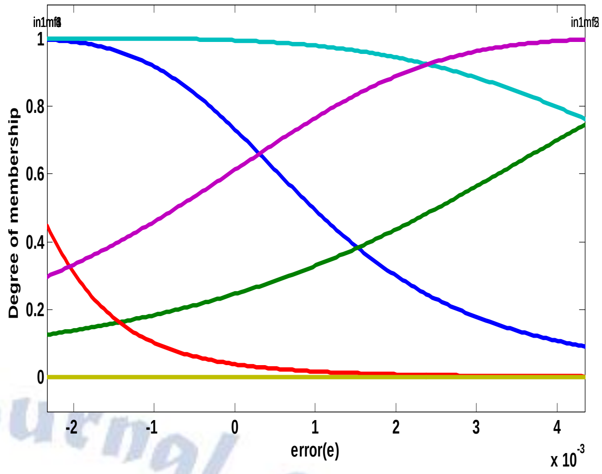

Fig. 7. Membership functions of first input error (e)

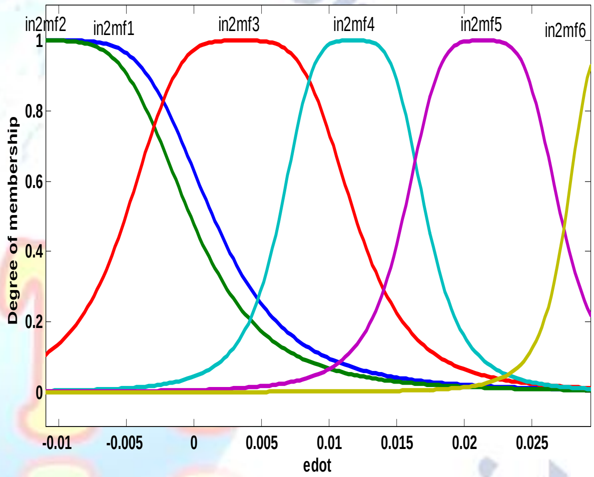

Fig. 8. Membership functions of second input change in error (edot)

III. Simulation Results

The performance of the PID-PSS and proposed ANFIS-PSS was evaluated by applying three phase fault at middle of one tie line at 1 sec which causes large disturbance and is cleared after 0.083 sec by opening the breakers. The PID power system stabilizer parameters is shown in table 1. Each generator parameters are based on data in Table 2.

Table 1: Parameter of PID controller

Parameter	Kp	Ki	Kd
G1	30	10	0.001
G2	10.50	0.67	0.45
G3	10.50	0.67	0.45
G4	10.50	0.67	0.45

To investigate the Inter area power oscillation damping performance of PID-PSS and proposed ANFIS-PSS with two-area four-machine test system, the three phases to ground fault was considered .A three-phase fault of 0.083 sec duration is simulated at line-1. Fig. 9 shows the plot of active power transfer response of system under without PSS condition. Fig. 10 presents the result of the examined active power transfer response under PID-PSS. While fig. 11 shows the response of active power transfer response with proposed ANFIS controller based power system stabilizer.

Table 2: Parameters of the generator

Parameter	Generator
Xd	1.8
Xd’	0.3
Xd”	0.25
Xq	1.7
Xq’	0.55
Xq”	0.25
Xt	0.2
Tdo	8
Tdo’	0.03
Tq	0.4
Tq’	0.05

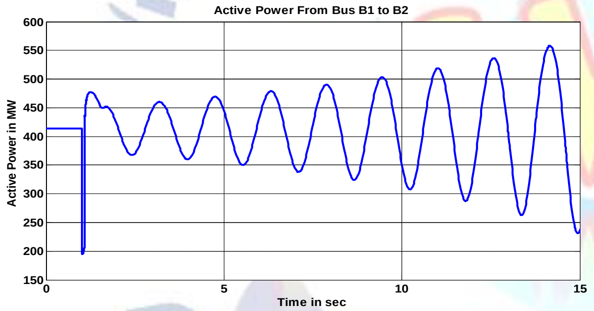

Fig. 9. Active Power which is transferred under three Phase fault condition without PSS.

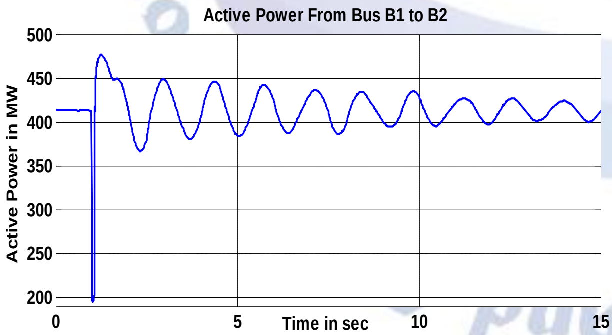

Fig. 10.PID power system stabilizer power transferred under 3 phase fault condition

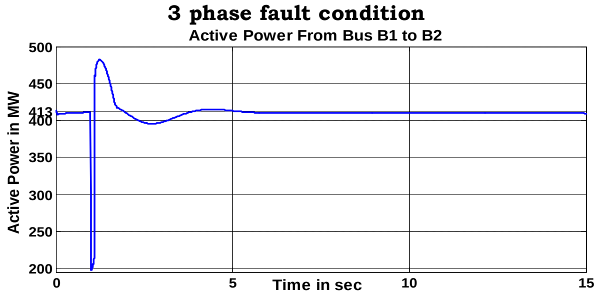

Fig. 11.ANFIS power system stabilizer Active Power transferred underthree Phase fault condition

From the above plots, the power oscillation damping performance obtained for three phase fault condition without PSS, with PID-PSS and proposed ANFIS based PSS, it is clearly observable that the proposed PSS is highly efficient in providing higher damping in the power oscillation as compared to the others. Furthermore the proposed controller requires only 5 sec to settle down the power transfer, which is very less as compared to the conventional PID controllers.

IV. Conclusion

This work forwarded a vigorous way to achieve fast and efficient damping of inter area power oscillations. With the development of the proposed ANFIS controller based PSS, an improved dynamic stability of interconnected power systems has been achieved by higher damping of active power oscillation in two area four machine power system. The basic aim was to use advantage of the adaptive neuro fuzzy inference based structure.

After the successful implementation of the proposed ANFIS controller based power system stabilizer (ANFIS-PSS), a complete testing process have been also presented by generating three phase to ground fault on the mid of the transmission line. The obtained results shows that the inter area power oscillation damping capability of proposed ANFIS controller based power system stabilizer (ANFIS-PSS) is much higher than the conventional PID-PSS.

In addition to this the results also indicates that, the proposed controller based power system stabilizer takes only 5 sec to completely damp the Inter area power oscillations, whereas PID-PSS takes even more than 15 sec to control the power oscillations.

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