Power System Stabilizer for Transient Distribution using Grey Fuzzy Controller

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Abstract – The present article describes about the designing procedure for a Grey ANFIS based power system stabilizer (Gr ANFIS-PSS) and investigates their robustness for a multi-machine power system. Speed deviation of a machine and its derivative are chosen as the input signals to the Gr ANFIS-PSS. A four-machine and a two-area power system is used as the case study. Computer simulations for the test system subjected to transient disturbances i.e. a three phase fault, were carried out and the results showed that the proposed controller is able to prove its effectiveness and improve the system damping when compared to a conventional lead-lag based power system stabilizer controller. Gr ANFIS-PSS is designed to damp out the low frequency local and inter-area oscillations of the Multi-machine power system. By applying this Gr ANFIS-PSS to the power system the damping of inter-area modes of oscillations in a multi-machine power system is handled properly.

Key Words: Grey Prediction, Power system oscillations, linear models, ANFIS

1.INTRODUCTION

The effectiveness of the proposed Gr ANFIS-PSS is demonstrated on two area four machine power system (Kundur system), which has provided a comprehensive evaluation of the learning control performance. Finally, several fault and load disturbance simulation results are presented to stress the effectiveness of the proposed GrANFIS-PSS in a multi-machine power system and show that the proposed intelligent controls improve the dynamic performance of the GrANFIS-PSS and the associated power network. To improve the damping of oscillations in power system, a Power System Stabilizers (PSSs) applied on selected generators can effectively damp local oscillation modes while for inter-area oscillations a supplementary controller can be applied. Most of these controllers are designed base on conventional approach that is designed based on a Linearized model which cannot provide satisfactory performance over a wide range of operation points and under large disturbances.

2. Body of Paper

The fuzzy inference systems for this system is a two input and one output first-order Takagi and Sugeno's fuzzy if-then rules and are used in the Gr ANFIS-PSS architecture with twenty five rules whose block diagram is illustrated here in Fig.1. The input to the Gr ANFIS-PSS is the speed deviation and change of speed deviation. The linguistic rules, considering the dependence of the plant output on the controlling signal, are used to build the initial fuzzy inference structure. The inputs scaling blocks maps the real input to the normalized input space in which the membership functions are defined. The output scaling block is used to map the output of the fuzzy inference system to the real output needed. The inputs signals are fuzzified using five fuzzy sets Ai and Bi, i=1 to 5. Any continuous and piecewise differentiable functions are qualified candidates for node functions of premise parameters of the ANFIS structure. This work considers the Gaussian function as the initial fuzzy membership function, with maximum equal to 1 and minimum equal to 0 and is given by

$$\mu_i(X) = exp\left[-\| x - c_i \|^2/\sigma_i^2\right] \quad (1)$$

Where ci is the center vector of the function, which has same dimension as input vector,σi is a specific parameter of the Gaussian function, and the Gaussian function μi has the only max value at the center ci. The initial values of premise parameters are set in such a way that the MF's are equally spaced in the range [-1 1]. The outputs of the inference system are linear membership functions and the rule base with five fuzzy if-then rules of (TS) Takagi and Sugeno's type given by

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if Δω is A1 and Δω(t-1) is A2 then fi = pi Δω + qi Δω(t-1) + ri (2)

Where Δω and Δω(t-1) are the inputs of the systems while A1 and A2 are fuzzy sets in the antecedent, and *pi*, *qi* and *ri* are the consequent parameters.

Table 1: Rules Extracted from the Conventional Controller

Speed Dev.	Acceleration						
NB	NB	NM	NS	ZE	PS	PM	PB
	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NM	NM	NS	ZE	PS
NS	NB	NM	NS	NS	ZE	PS	PM
ZE	NM	NM	NS	ZE	ZE	PM	PM
PS	NM	NS	ZE	ZE	PS	PM	PB
PM	NS	ZE	PS	PM	PM	PM	PB
PB	ZE	ZE	PM	PS	PB	PB	PB

Design of Grey ANFIS based power system stabilizer (Gr ANFIS-PSS)

In grey systems theory, prediction error is used instead of current measured error. In similar lines, during the development of the Grey ANFIS based power system stabilizer (Gr ANFIS-PSS), the prediction error is considered as the error of the system. The block diagram of the Grey ANFIS based power system stabilizer (Gr ANFIS-PSS) is proposed in this paper is showed in Fig.1.

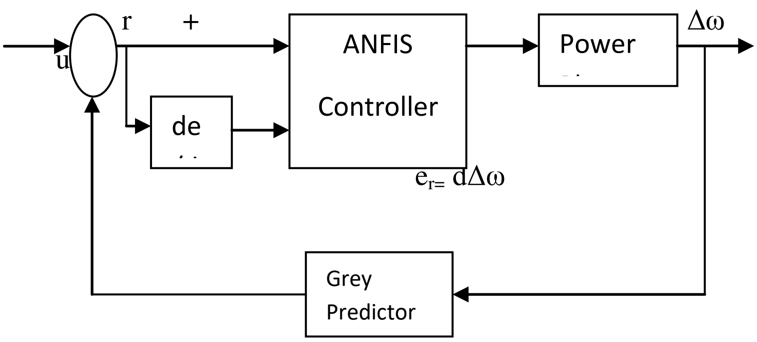

Fig.1 Block diagram of the Grey ANFIS based power system stabilizer (Gr ANFIS-PSS)

Three phase to ground fault

Three phase to ground fault locating at 60 % of the distance along line is applied at *t=0.55* s. and the fault is cleared at *t=0.758* s. Responses without stabilizer and with conventional PSS and.

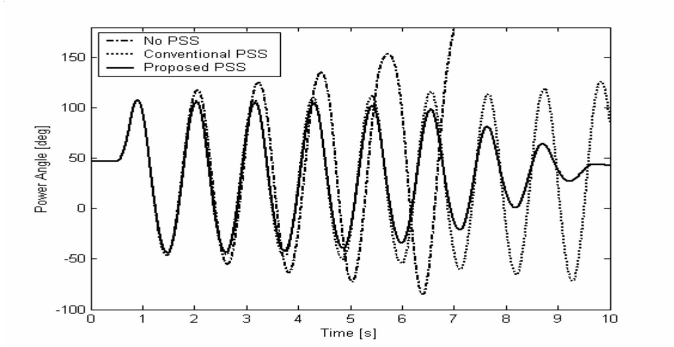

Fig.2 Three phase to ground fault.

Proposed PSS. Systems without stabilizer and with conventional PSS are both unstable. The system with proposed Gr ANFIS-PSS is highly oscillatory, but it is stable.

The single-line diagram of the two-area, 4-machine test system, as shown in Fig.3, is used to examine both local and inter-area oscillations control problems. This system is created especially for the analysis and study of the inter-area oscillation problem. As shown in the above single-line diagram there are four generators, G.1 and G.2 for area-1, G.3 and G.4 for area-2, and four 20/240 kV step-up transformers. There are two loads in the system at buses 3 and 13. This system exhibits three electromechanical modes of oscillations where one inter-area mode of the generating units in one area oscillates against those in the other area. The frequency of this mode varies from 0.45 to 0.85 Hz depending on the operating conditions. Two local modes represent oscillations between the generating units within each area. The frequency of the local modes is around 1.8 Hz and the loads are modeled as constant impedances. One set of GrANFIS-PSS controllers is used for generator number one and one conventional-PSS for generator number two.

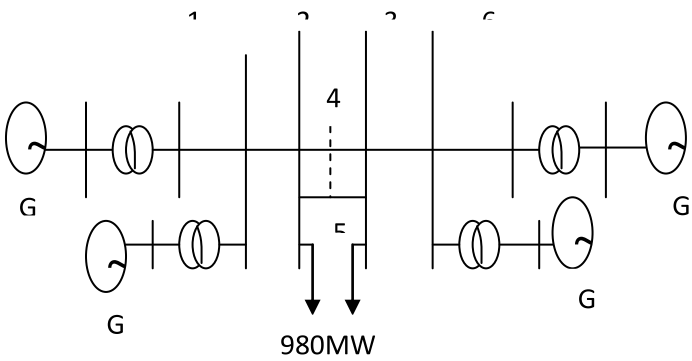

Fig. 3 Two Area, 4-Machine Test

Conclusion

In this Work, Gr ANFIS-PSS is proposed for damping oscillations and the effectiveness of the proposed control system is compared with Conventional controller under some disturbances. The controller is tested on a well known bench mark power system model proposed by Kundur called two area four machines system. From the results it can be concluded that the Gr ANFIS-PSS produces no steady state error and acceptable overshoot under some disturbances. The work in this research involves a design of Gr ANFIS-PSS, which is built based on the data generated by the conventional controller. This power system is supporting the Economic group of the country.

REFERENCES

[1] Momoh J.A., EL-Hawary M.E.,“ Electric systems, dynamics, and stability with artificial intelligence applications,” Marcel Dekker, New York, 2000.
[2] Kundur P., “Power System Stability and Control”, Mc-Graw Hill Press, 1993.
[3] Noroozian M., Andersson G., “Damping of inter-area and local modes by use of controllable components,” IEEE Transactions on Power Delivery, Vol. 10, No. 4, pp. 2007-2012,1995.
[4] Hsu Y.Y.,Chen C.R.,“Tuning of fuzzy power system stabilizers using artificial neural network,” IEEE Transactions on Energy Conversion, Vol. 6, No. 4, pp. 612-619,1991.
[5] Chen X.R., Pahalawaththa N.C., Annakkage U.D., Kumble C.S.,“Design of decentralized output feedback TCSC damping controllers by using simulated annealing,” IEE Proceedings on Generation, Transmission and Distribution, Vol.145, No. 5, pp. 553-558, 1998.