

TRANSIENT STABILITY PERFORMANCE COMPARISON OF FUZZY LOGIC BASED PSS AND GWO BASED PSS

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ABSTRACT. In this paper, the performance of Fuzzy Logic Controller based PSS (FLPSS) and Grey Wolf Optimizer based PSS (GWOPSS) are examined. In this paper, two controllers like FLPSS and GWOPSS are proposed for the 3 machines 9 bus system for the improvement of transient stability. Here three power system stabilizers are connected to three generating stations, in the case of FLPSS three different fuzzy logic controllers are designed based on the frequency error and change in the frequency error. In the case of GWOPSS, the parameters of three power system stabilizers are evaluated using a grey wolf optimization algorithm. The performance of both controllers is compared together by creating fault between buses 5 and 7 & 6 and 9. From the results, it is concluded that GWOPSS is effectively enhancing transient stability compared with FLPSS.

1. INTRODUCTION

In general, the power system is highly nonlinear and inter-connected. Due to interconnections between various areas of the power system, the frequency oscillations of one are affecting the frequency of other areas. Depending on the magnitude of frequency oscillations, there two stability analyses first one is dynamic stability analysis and the second one is transient stability analysis.

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Transient stability analysis is very important; if this is not improved system collapse will take place. Therefore, transient stability is considered in this paper. The authors of [1] presented a power system stabilizer for stability enhancement. These authors proposed different methods for designing PSS, but after design, these parameters of controllers are fixed that means at the time of design only one operating point is considered. Therefore, if the operating point of the power system changes, the effectiveness of PSS is changing.

The authors of [2] proposed a self-tuning power system stabilizer (STPSS) for stability enhancement of a multi-machine power system. Hsu et al., proposed fuzzy logic controller type power system stabilizer for a multi-machine power system stability enhancement [3]. In this paper, the conventional power system stabilizer is replaced with a fuzzy logic controller and the design of this controller depends upon expert knowledge. Zhang et al. proposed artificial neural network-based PSS for enhancing the stability of the power system [4]. In this paper tuning of the neural networks requires history. These methods require expert knowledge or past data and these are affecting the performance of PSS. Abido et al. proposed a hybrid power system stabilizer using a genetic algorithm for oscillations damping [5]. Afzalian et al. proposed a neuro-fuzzy power system stabilizer using a genetic algorithm for stability enhancement [6]. Lakshmi et al., proposed fuzzy logic and genetic algorithm based power system stabilizer for multi-machine stability [7]. Wang proposed a modified genetic algorithm-based PID controller for oscillation damping [8]. Dhana Selvi et al. proposed a Grey wolf optimizer algorithm based PSS for multi-machine system stability enhancement [9]. The papers propose different methods for stability enhancement but are facing problems due to changes in the operating conditions or changes in the fault locations and types. In this paper, two controllers are proposing three machine nine bus systems and tested under different fault conditions. From the results, we concluded that both are working effectively. In comparison, GWO based PSS is giving better performance compared with Fuzzy based PSS.

This paper is organized into five sections, the first section represents the introduction, second section, and third sections are respectively fuzzy logic & GWO controllers. The fourth section deals with simulation results. The fifth section presents conclusions.

2. DESIGN OF FUZZY LOGIC BASED PSS

In general power system stabilizer is a combination of three blocks, 1. Gain, 2. lead/lag, and 3. Wash out. Based on the damping frequency magnitude the number of lead/lag blocks is changing. In this paper, we replaced all three blocks with only one controller known as a fuzzy logic controller. The design of this controller is explained through Fig. 1(A-F). For these controllers, the

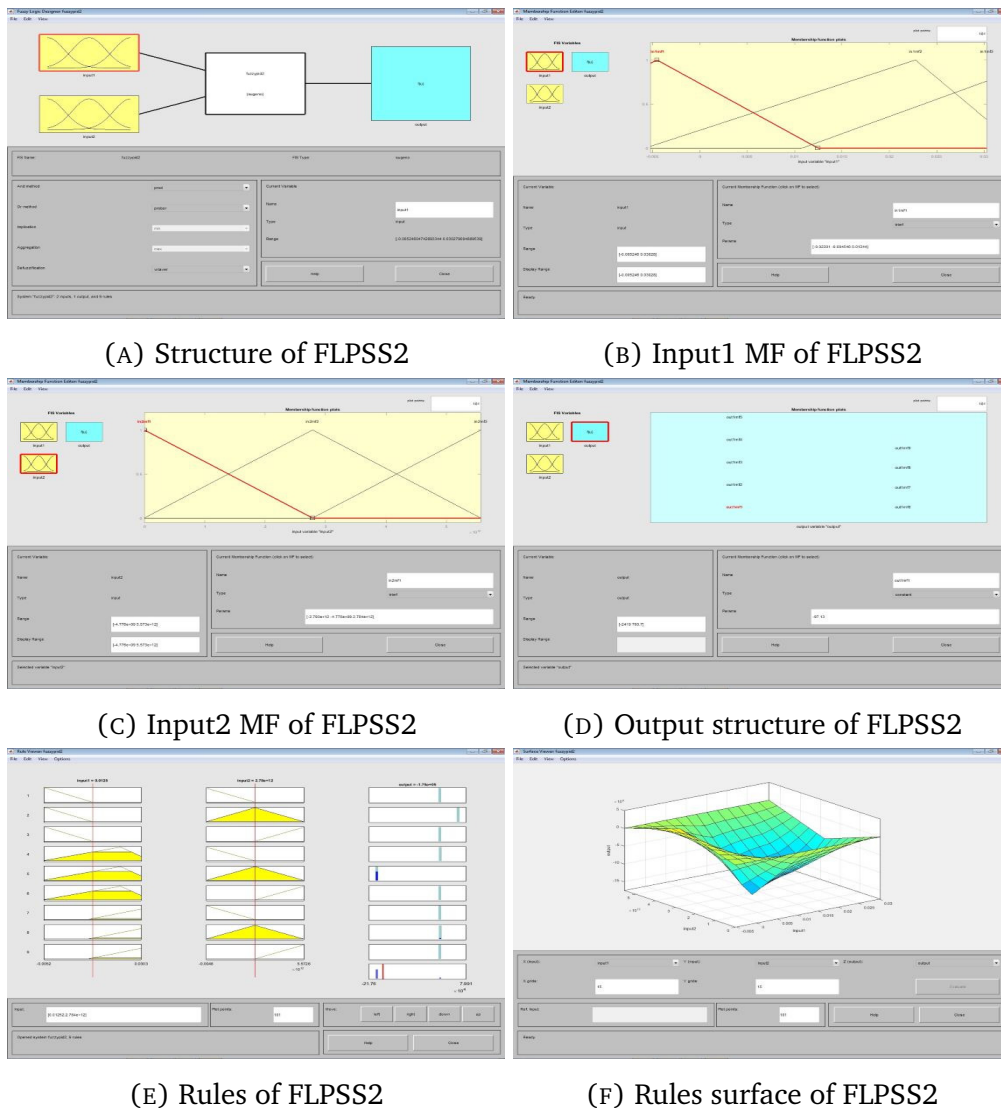


FIGURE 1. Design of FL based PSS controller

error is speed deviations of all the three machines and change in error is the

differentiation of error. The output of these controllers are applied to generator voltage reference, from this output is applied to electrical power, then speed deviations will be reduced. Fig. 1 shows the structure of a fuzzy logic controller of PSS1. From this, it is concluded that this is using two inputs and one out for each controller. In this paper, three fuzzy logic controllers are developed for three generators.

Input membership function (MF) and output pattern functions are shown in Fig. 1(B-D). Fig. 1(E-F) shows the rules and rule surface of PSS. Here input1 is the frequency error of generator 1 and input2 is the change in frequency error of generator 1. The design of PSS1 and PSS3 is similar to that controller.

3. DESIGN OF GWO BASED PSS

GWO algorithm is an advanced optimization algorithm, which involves hire order in the search of prey [10]. The following steps are used for the design of PSS:

1. Initialization of requiring parameters for Iterations, searching agents, tuning parameters, ranges for α, β, Δ , and ω and integral time area error.
2. Run the simulation file over a specified period with initial values and re-evaluate ITAE.
3. α, β , and Δ values are updated.
4. Update the searching positions of α, β, Δ , and ω using the following equations:

$$A_1 = 2a_1r_{n1}a_1$$

$$B_1 = 2r_{n2}$$

$$C_\alpha = B_1P_\alpha - Best_\alpha$$

$$C_\beta = B_1P_\beta - Best_\alpha$$

$$C_\Delta = B_1P_\Delta - Best_\alpha$$

$$B_\omega = B_1P_\omega - Best_\alpha$$

5. Update the parameters of PSS with new values.
6. Run simulation file with updated PSS parameters and evaluate ITAE and repeat the procedure from step 3.
7. Stop the optimization procedure once iterations are completed.

The parameters of power system stabilizer gains and time constants of these controllers are optimized using the GWO algorithm as per the given procedure. Here integral time area error is the measure of speed deviations.

4. TEST SYSTEMS AND SIMULATION RESULTS

The proposed controllers are applied to three machine nine bus system. The results are shown in Figs. 2-4, respectively. Fig. 2(A) shows delta variations of machine 1 with two proposed controllers. From this, it is noticed that fuzzy logic controller based PSS increasing the oscillations, whereas GWO based PSS maintains oscillations constantly. Fig. 2(B) shows delta variations of machine

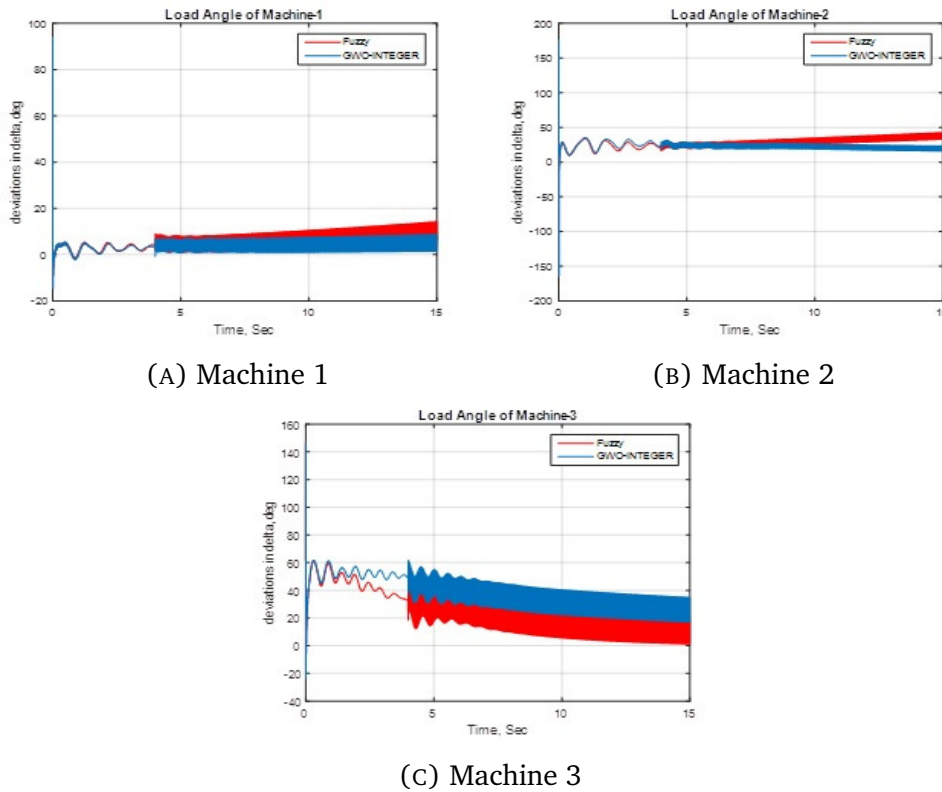


FIGURE 2. Deviations in the delta

2 with two proposed controllers. From this, it is noticed that fuzzy logic controller based PSS increasing the oscillations, whereas GWO based PSS maintains oscillations constantly.

Fig. 2(C) shows speed variations of machine 3 with two proposed controllers. From this, it is noticed that fuzzy logic controller based PSS increasing the oscillations, whereas GWO based PSS reduces to 0.97 p.u.

Fig. 3(A) shows speed variations of machine 1 with two proposed controllers. From this, it is noticed that fuzzy logic controller based PSS increasing the oscillations, whereas GWO based PSS reduces to 0.98 p.u. Fig. 3(B) shows speed

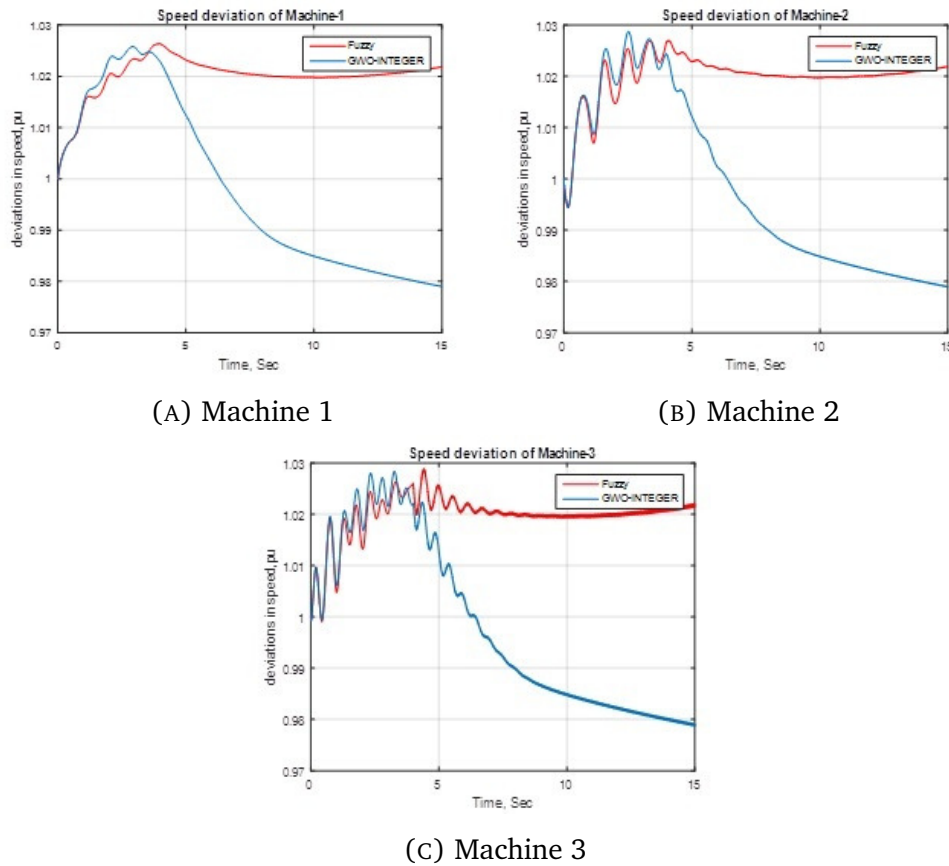


FIGURE 3. Deviations in the speed

variations of machine 2 with two proposed controllers. From this, it is noticed that fuzzy logic controller based PSS increasing the oscillations, whereas GWO based PSS reduces to 0.98 p.u.

Fig. 3(C) shows speed variations of machine 3 with two proposed controllers. From this, it is noticed that fuzzy logic controller based PSS increasing the oscillations, whereas GWO based PSS reduces to 0.981 p.u.

Fig. 4(A) shows electrical power variations of machine 1 concerning time. From this figure it is clear that GWO based PSS damping the oscillations and reached steady-state power of 1 p.u. the fuzzy logic controller based PSS not damping effectively and also not reached steady state. Fig. 4(B) shows electrical

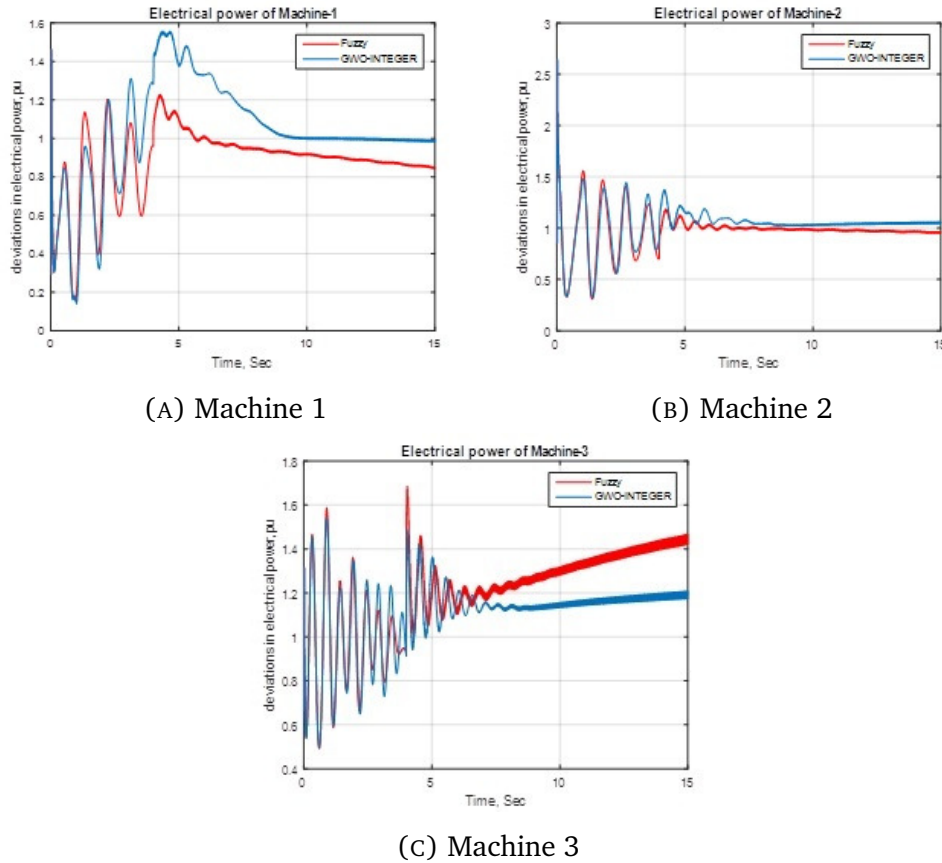


FIGURE 4. Deviations in the electrical power

power variations of machine 2 concerning time. From this figure, it is clear that GWO based PSS damping the oscillations and reached steady-state power of 1 p.u. the fuzzy logic controller based PSS not damping effectively and also reached steady state with small oscillations.

Fig. 4(C) shows electrical power variations of machine 3 concerning time. From this figure, it is clear that GWO based PSS damping the oscillations and reached steady-state power of 1.2 p.u. the fuzzy logic controller based PSS not damping effectively and also not reached steady state.

From the results, it is indicated that the proposed controller is effectively damping the oscillations as compared with the fuzzy logic controller.

5. CONCLUSION

In this paper, two controllers namely Fuzzy logic controller based PSS and GWO based PSS are proposed for the enhancement of transient stability. These proposed controllers are implemented and tested on three machine nine bus system. From the results, it is concluded that among two proposed controllers, GWO based PSS is damping the oscillations effectively compared with fuzzy logic controller based PSS.

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