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Power Stabilizer Performance Based On Fuzzy Controller Compared To PID Controller

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Abstract

Electro-mechanical oscillations are produced in the machines of an interconnected power network, followed by a disturbance or due to high power transfer through weak tie lines. These oscillations should be damped as quickly as possible to ensure the reliable and stable operation of the network. To damp these oscillations different controllers, based on local or wide area signals, have been the subject of many papers. This paper presents the analysis of the PID of Conventional Power System Stabilizer (PSS) and Fuzzy Logic Controller.

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1. Introduction

Excitation control system is an important part of Power System, of which the main task is to maintain generator terminal voltage and balance reactive power. Excitation control system of the large synchronous generator has an important effect on the stability of Power System. With the increase of unit capacity and the scale of Power System, more demands have been put forward in the aspects of rapidity, reliability and versatility. [1] As a complex nonlinear system, it is difficult to establish an accurate mathematical model for the excitation control system. Therefore, scholars proposed many new controlling theories, such as optimal control theory, fuzzy set theory, neural network, genetic algorithm etc., and put them into the application of excitation control system.[2]. The excitation control of a synchronous generator using Proportional Integral Derivative (PID) control is considered in this paper. The proposed PID Power system stabilizer employs the generator frequency and voltage deviations to provide a supplementary signal for the excitation control. The gains of the PID controller are calculated for complete pole placement. Digital simulation of a synchronous machine subject to a disturbance is performed to demonstrate the effectiveness of the proposed controller. It is found that the proposed PID stabilizer outperforms the traditional power system stabilizer currently used by most power plants.[3] The basic principles of GA were first proposed by Holland [4]. Genetic algorithm is a robust optimization technique based on natural selection. The major objective of the GA is to determine the optimal values of the PID controller parameters to improve the transient response of the system. To achieve this, the algorithm considers the maximization of an objective function. This objective function provides a means for evaluating the performance of the PID controller with the determined gain parameters, so that an optimized controller would be developed by the best individual. When applied to the PID controller design problem, the genes are the gain values of the controller KP, KI, and KD which are to be determined. Each chromosome contains a complete set of the genes needed to define uniquely a trial solution. The fitness of each chromosome is evaluated using the error criterion, which is used as the basis of selection for the chromosomes in the next generation.[4] The steps involved in creating and implementing a genetic algorithm are as follows:

- Generate an initial, random population of individuals for a fixed size (according to conventional methods KP, kI, kD ranges declared).
- Evaluate their fitness (to minimize integral square error).
- Select the fittest members of the population.
- Reproduce using a probabilistic method (e.g. Roulette wheel).
- Implement crossover operation on the reproduced chromosomes (choosing probabilistically both the crossover site and the 'mates').
- Execute mutation operation with low probability.

Repeat step 2 until a predefined convergence criterion is met. The summary of the process will be described in Fig.1 below

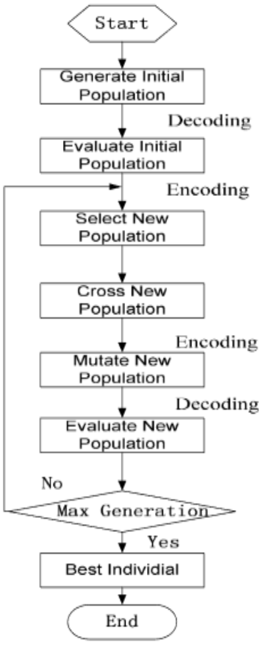

Fig. 1. Flow Diagram of genetic algorithm

2. Synchronous generator modeling:

Because the generator has an internal impedance and in stability studies, we need the size and angle of the internal voltage, we must obtain a more suitable equivalent circuit for stability studies. Therefore, we consider the following equivalent circuit.

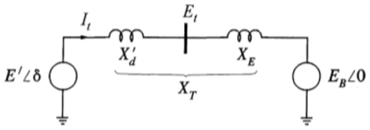

Fig. 2. Equivalent circuit suitable for stability studies

$$P = \frac{E'E_B}{X_T}\sin\delta \tag{1}$$

In this relation, δ is the angle between the internal voltage of the generator and the bus is infinite. In a peritonised system, the values of power and torque are equal to each other, and if we ignore the internal losses of the generator, the relationship between the power obtained and the internal torque of the generator will be equal, so we have:[5]

$$T_e = P = \frac{E'E_B}{X_T}\sin\delta \tag{2}$$

If you do the linearization around the nominal point (δ = δ_0), you should have:

$$\Delta T_e = \frac{\partial T_e}{\partial\delta}\Delta\delta = \frac{E'E_B}{X_T}\cos\delta_0(\Delta\delta) \tag{3}$$

On the other hand, the dynamic relationship of velocity by considering the damping torque component will be as follows.

$$p\Delta\omega_r = \frac{1}{2H}(T_m - T_e - K_D\Delta\omega_r) \tag{4}$$

Considering the above two relations, we can write:

$$p\Delta\omega_r = \frac{1}{2H}\left[\Delta T_m - K_S\Delta\delta - K_D\Delta\omega_r\right] \tag{5}$$

Therefore, the block diagram of the synchronous generator connected to the infinite bus will be as shown below. In this section, we simulate stabilization pid and the effects of this type of controller on the stability of the generator can be seen. For this, it is enough to first draw a Phillips Hepheron fashion as shown in Figure 3.[6]

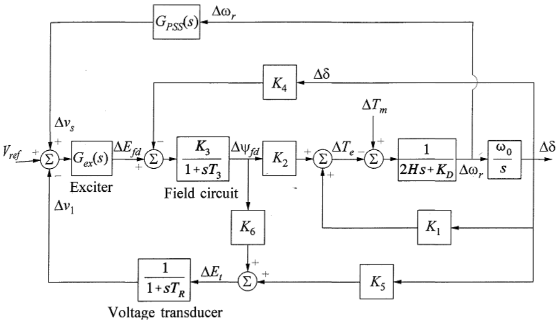

Fig. 3. Synchronous generator diagram block with AVR and PSS

After the simulations, we will see the effects of the classic controller on the generator model in Figure 4. The results of a classic controller can be seen in a Philips Hefron model based on Figure 5 and Figure 6.

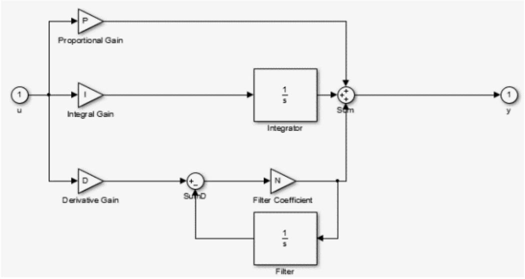

Fig. 4. Classic controller PID

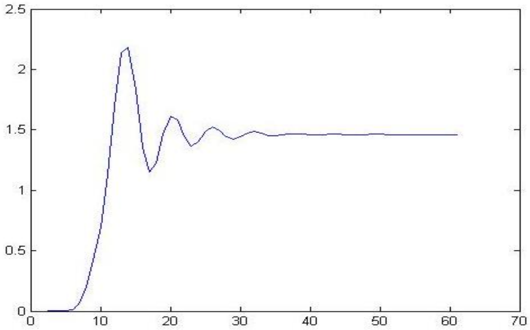

Fig. 5. Changing the rotor angle

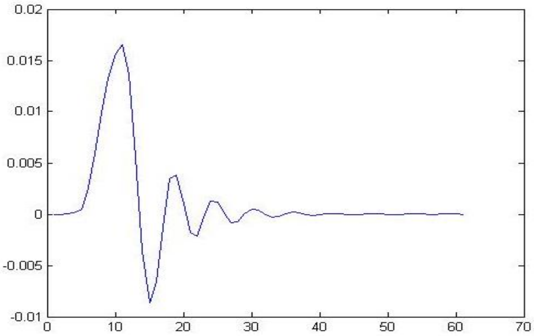

Fig. 6. Speed changes

In general, design of fuzzy logic controllers (FLC) requires a complete control rule bases .By completeness, we mean that the FLC can generate control for any input signals. This can be achieved by defining the membership functions of each input variable covering ions. Obviously, it involves a significant work and cost. Besides that, at the time of constructing the controller the plant's behaviours have not be thoroughly explored, so, the designer often lacks sufficient knowledge to fulfil the complete rule base. However, in practice a complete control rule base is not necessary for many applications where some states in the input domain are hardly to occur. Instead of a complete rule base, it is widely accepted that a well-designed sparse rule base may compromise the controllers performance and the implementation cost. One approach, which takes into account these issues, is the self-organizing fuzzy logic controller (SOFC) with rule generating mechanism its whole domain and constructing the rules for all possible conditions [7]. This article uses me to see you using the classic controller above. Displays the fuzzy controller to allow designers to use the controller for better conditions. The basic operations performed in the design of a fuzzy controller are fuzzification, formation of the rule base, inference mechanism, and defuzzification. The process of fuzzification involves measurement of input variables and converting input data into suitable linguistic values, which may be the labels of fuzzy sets. Fuzzy sub- sets contain elements with different degrees of membership. A fuzzy membership function [0,1] assigns a real number between 0 m3:x an 1 to every element x in the universe of dis- come X. The number m (x) indicates the membership functions can have different shapes like triangular, trapezoidal and exponential. In practice, triangular shapes are easy for computation purposes and hence are commonly used. When .finer control is desired, narrow membership functions are desired whereas broader membership functions are sufficient for the purpose of rough control. Hence, it is desirable to have a membership function generator with variable slope. To represent different fuzzy sets like NL, NM, NS, ZR, PS, PM, PL, it is desirable to have member- ship functions where the range of the membership function is variable. It is also desirable to obtain variable peak voltage in the membership functions since; changing the peak voltage changes the degree of membership of the elements in a fuzzy set. The rule base consists of linguistic control rules usually of the “if-then" form. These rules are obtained from expert (operator) experience and control engineering knowledge.[8]

The development of the control system based on fuzzy logic involves the following steps:

- Selection of the control variables
- Membership function definition
- Rule formation

3. Defuzzification Strategy

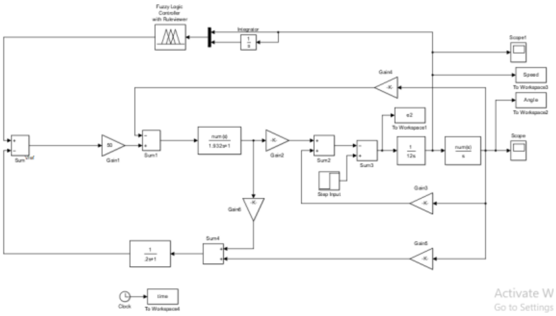

Fig. 7. Philips Hefron model with fuzzy controller

As shown in Figure 7, we have shown the fuzzy controller design for a Philips Hefron model, noting that we have chosen speed and derivative as the input of the fuzzy controller, for which designers have a variety of methods. In the following set, we state the rules for our controller base on Figure 8.

e (1/s)e	NB	NS	ZO	PS	PE
NB	NB	NB	NB	NS	ZO
NS	NB	NB	NS	ZO	PS
ZO	NB	NS	ZO	PS	PB
PS	NS	ZO	PS	PB	PB
PB	ZO	PS	PB	PB	PB

Fig. 8. Set of fuzzy rules

Now, by obtaining a set of fuzzy rules, which is a work in terms of trial and error and in terms of experience, we will perform the simulation based on Figure 9 and 10.

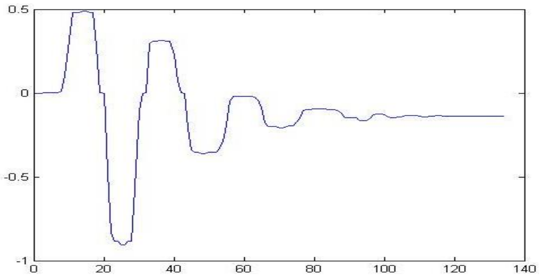

Fig. 9. Rotor Angel

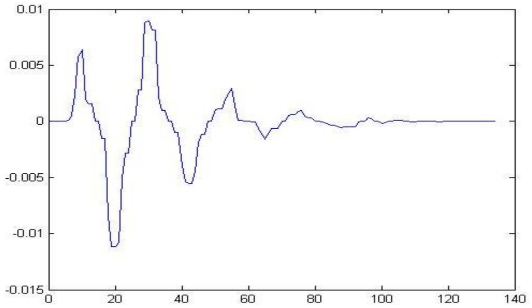

Fig. 10. Speed changes

4. Conclusion

As we can see in the simulation, the simulation times are the same in each of the controllers. Although we have achieved good results in the cluster controllers, it should be noted that its coefficients have always been constant with the error rate. For this reason, we recommend the fuzzy controller, because with the amount of error, the input values also change, and the results can always provide a better degree of stability than the classic controller can.

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