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A COMPREHENSIVE REVIEW ON POWER SYSTEM STABILITY ENHANCEMENT WITH DIFFERENT SOFT COMPUTING TECHNIQUES

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Abstract: In the proposed manuscript fuzzy based power stabilizer is to be designed for a single machine infinite bus bar (SMIB) system. The whole work is to be carried out in a simulation software. The simulation are to be carried out on a state space model of SMIB Energy system with fuzzy logic controller and conventional controller in the presence of small disturbance in the system. The effectiveness (steady state error, overshoot & settling time) of fuzzy controller is to be compared with the conventional PSS. Further the complexity of proposed fuzzy PSS may be reduced by reducing the number of fuzzy rules. This simple design approach and smaller rule base is easy to realize and can provide better performance compared with the conventional power system stabilizer and fuzzy logic power system stabilizer.
Keywords: Heffron-Philips model, Low Frequency Oscillations (LFO), Fuzzy Logic Controller (FLC), Power System Stabilizer (PSS), Conventional power System Stabilizer (CPSS) Controller Membership functions.

I. INTRODUCTION

Power system stability can be classified into: Transient stability and Small signal stability. There has been spontaneous system oscillations with frequencies ranging from 0.1 to 2 Hz are inherent to electric energy system. The conventional power plant of the early 19th century was equipped with continuously acting automatic voltage regulators to improve the transient stability of the system. As these conventional controllers have high gain so it has a destabilizing effect on power system network and these controllers are designed for a specific operating condition so they cannot maintain a desired level of performance when the system operating condition changes. The solution to this problem is provided by fuzzy logic which is remarkably is a simple way to draw definite conclusion from vague, ambiguous or imprecise information. Fuzzy Logic has the features of simple concept, easy implementation, and computationally efficient. So, in this manuscript the fuzzy logic based power system stabilizer model is evaluated on a single machine infinite bus (SIMB) power system, and then the performance of Conventional power system stabilizer (CPSS), Fuzzy logic based Power system stabilizer (FLPSS) are to be compared. The paper is organized as follows; Section II describes the modelling of proposed system and its linearized model. The design of the conventional Power system stabilizer and Fuzzy logic based Power system stabilizer is detailed in Section III. The simulation results are presented and discussed in Section IV. The conclusion is mentioned in Section V. Appendix A includes various parameters of the system and controllers.

II. POWER SYSTEM MODELLING

SMIB (Single Machine Infinite Bus) system consists of a synchronous machine connected to an infinite bus through a transmission line.

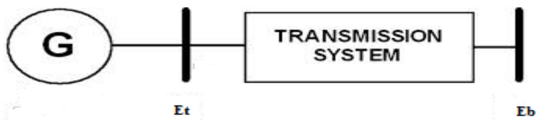


Fig. 1.Single machine infinite bus

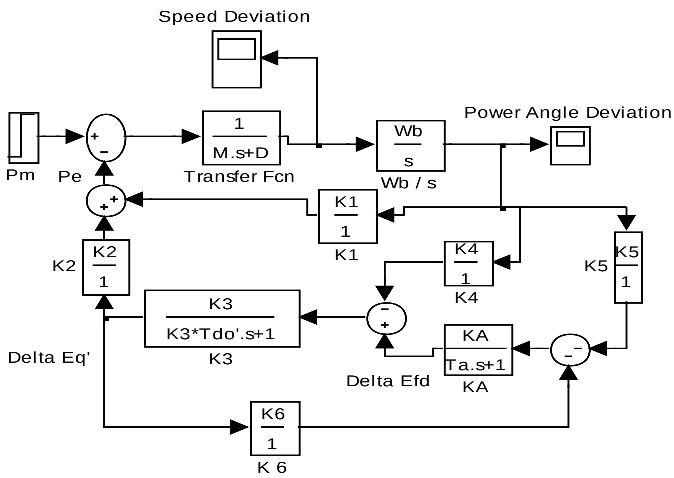


Fig. 2. Simulation Model of Heffron and Phillips without Controller

Fig.2.shows the block diagram of *Single Machine infinite bus model* (SMIB). This diagram was developed by Heffron and Phillips [1952] to represent the dynamics of a single synchronous generator connected to the grid through a line. This model is a well-known model for synchronous generators. This model is a linear model; still it is quite accurate for studying low frequency oscillations and stability of power systems. It has also been successfully used for designing classical power system controllers, which are still active in most power utilities

III. CONTROLLER

Concept of fuzzy logic has been given by LotfiZadeh in 1965. This logic is used in many applications in the industry because of some advantages: simple and faster methodology, reduce a design development cycle, simple to implement, reduce hardware cost, improve the control performance, simplify design complexity. So it is used as a controller in a power system as a fuzzy power system stabilizer [12-20]. The designing process is carried out with the help of MATLAB 2009a. A fuzzy controller comprises of three stages: fuzzification, fuzzy rule and defuzzification

Fuzzification

Fuzzification is the process of making a crisp quantity to fuzzy thefuzzification interface converts input data into suitable linguistic variables that can be viewed as label fuzzy sets. In this system there are two input speed and acceleration which is converting into fuzzy value. Usually an odd number is used. A reasonable number is seven. However,increasing the number of linguistic variables results in a corresponding increase in the number of rules. Each linguistic variable has its fuzzy membership function. So Seven membership functions is generating better result proved by some testing so as in, seven membership functions are defined. The linguistic labels of membership functions are marked as in fig. 6

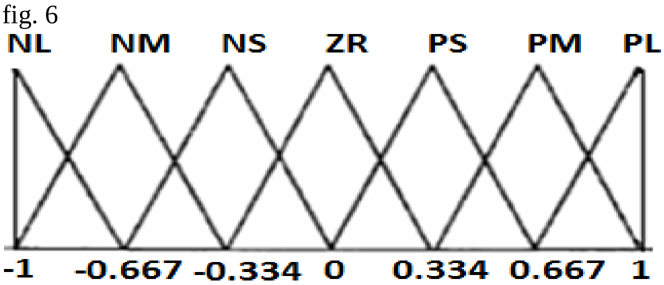


Fig. 5Membership functions for Fuzzy controller for input and output variable

Seven membership functions is generating better
Result proved by some testing so these are defined as
NH (Negative High),
NM (Negative Medium),
NS (Negative-Small),
ZR (Zero),
PS (Positive-Small),
PM (Positive-Medium),
PH (Positive High)

Membership functions are used to convert the fuzzy values between 0 and 1 for inputs and output value both. Membership functions are used to convert the fuzzy values between 0 and 1for inputs and output value.

Table 1: Rule base of fuzzy logic

Speed Deviation	Acceleration						
	NH	NM	NS	ZR	PS	PM	PH
NH	NH	NH	NH	NH	NM	NM	NS
NM	NH	NM	NM	NM	NS	NS	ZR
NS	NM	NM	NS	NS	ZR	ZR	PS
ZE	NM	NS	NS	ZR	PS	PS	PM
PS	NS	ZR	ZR	PS	PS	PM	PM
PM	ZR	PS	PS	PM	PM	PM	PH
PH	PS	PM	PM	PH	PH	PH	PH

Fuzzy rule base system

Fuzzy rules are defined to reduce the error in the system after analyzing the function of controller. For each fuzzy value there are seven membership functions, so 49 combinations of speed and acceleration are possible. There is an output for each of the membership functions and the linguistic variables can be determined by using IF–THEN fuzzy rules in the following form:

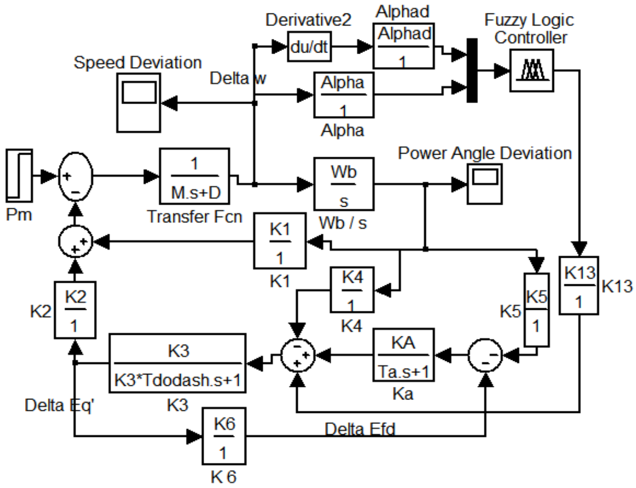
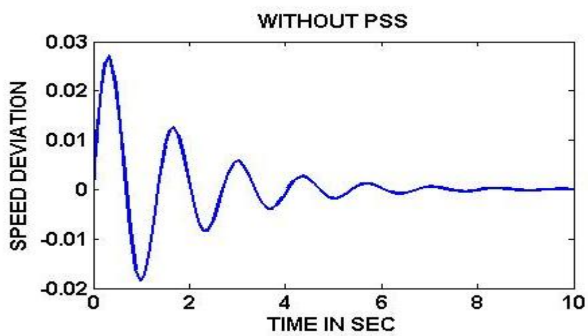


Fig. 6 Simulation Model of Plant Controlled by Fuzzy Power System Stabilizer

IV. SIMULATION RESULTS

Fig.7-12 shows the Speed Deviation (Δω) ,Power angle Deviation (Δδ) of the SMIB system without controller, controlled by conventional controller, FLC for the different type of membership functions. The System parameters (a) Speed Deviation (Δω) (b) Power angle Deviation (Δδ) of Generator obtained with the proposed controllers are given in Table II

The Output of SMIB system without PSS (a) Speed Deviation (Δω) (b) Power angle Deviation (Δδ) of Generator is shown in Fig. 7. The above response is clearly shows that system has large overshoot (Mp), large settlingtime (ts) & error steady state is 0 & 2 for for Speed Deviation and Power angle respective



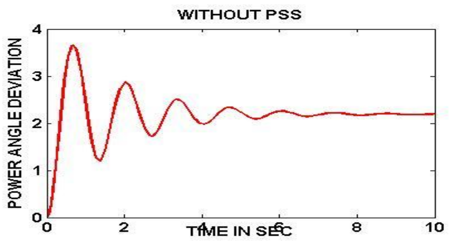


Fig. 7 Output of SMIB system without PSS (a)Speed Deviation (Δω) (b) Power angle Deviation (Δδ) of Generator

The Output of SMIB systems with conventional PSS (a) Speed Deviation (Δω) (b) Power angle Deviation (Δδ) of Generator is shown in Fig. 8. The above response shows that system has still larger overshoot (Mp), larger settling time (ts) & error steady state is 0 & 2 for Speed Deviation and Power angle respectively .This can be further improved by fine tunning of controller parameters.

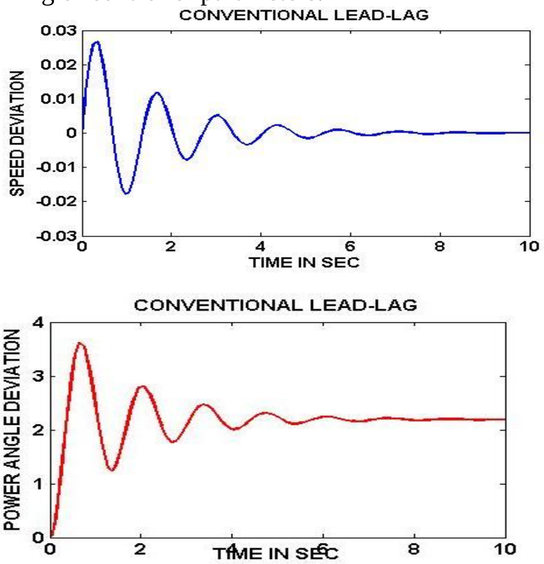
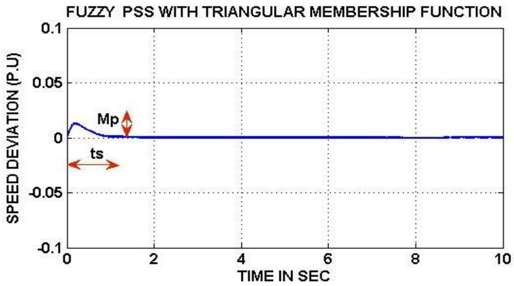


Fig. 8 Output of SMIB system conventional lead-lag PSS (a) Speed Deviation (Δω) (b) Power angle Deviation (Δδ) of Generator

The Output of SMIB system with Fuzzy PSS for a triangular membership function (a) Speed Deviation (Δω) (b) Power angle Deviation (Δδ) of Generator are shown in Fig. 9. The above response shows that system has smaller overshoot (Mp), smaller settling time (ts) & error steady state is 0 & 2 for Speed Deviation and Power angle respectively .So performance improved by using Fuzzy PSS. This can be further improved by fine tuning of controller parameter.



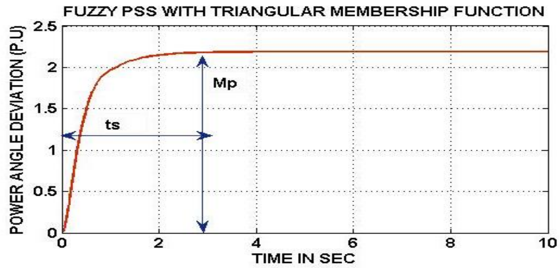


Fig. 9 Output of SMIB system fuzzy PSS for triangular membership function (a) Speed Deviation (Δω) (b) Power angle Deviation (Δδ) of Generator

The Output of SMIB system with Fuzzy PSS for a Trapezoidal membership function (a) Speed Deviation (Δω) (b) Power angle Deviation (Δδ) of Generator are shown in Fig. 10. The above response shows that system has smaller overshoot (Mp), smaller settling time (ts) & error steady state is 0 & 2 for Speed Deviation and Power angle respectively. So performance improved by using Fuzzy PSS. This can be further improved by fine tunning of controller parameters.

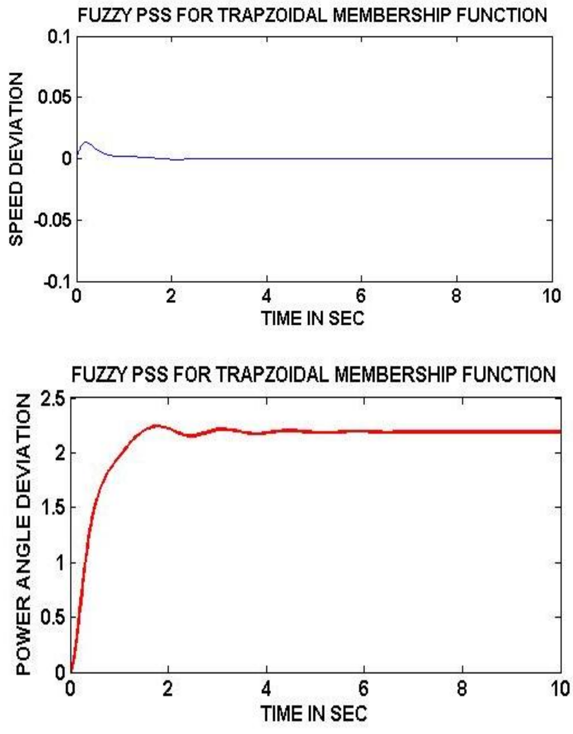


Fig. 10 Output of SMIB system fuzzy PSS for trapezoidal membership function (a) Speed Deviation (Δω) (b) Power angle Deviation (Δδ) of Generator

The Output of SMIB system Fuzzy PSS for a Gaussian membership function (a) Speed Deviation (Δω) (b) Power angle Deviation (Δδ) of Generator are shown in Fig. 11. The above response shows that system has smaller overshoot (Mp), smaller settling time (ts) & error steady state is 0 & 2for Speed Deviation and Power angle respectively. So performance improved by using Fuzzy PSS. This can be further improved by fine tunning of controller parameters.

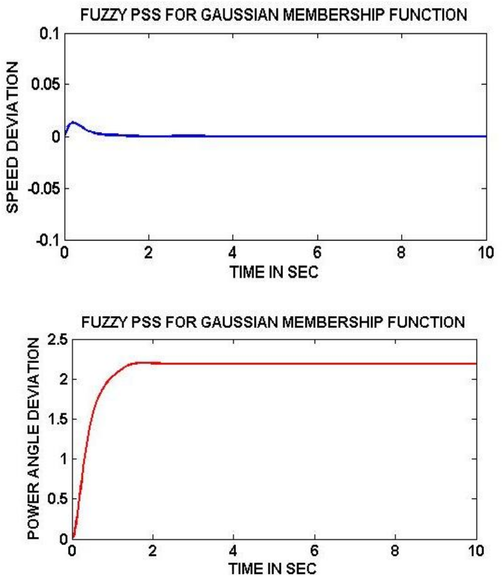


Fig. 12 Output of SMIB system fuzzy PSS for gaussian membership function (a) Speed Deviation (Δω) (b) Power angle Deviation (Δδ) of Generator

The Fuzzy logic Power system stabilizer has realized using different membership function and the results show that Gaussian membership function gives better performance.

V. CONCLUSION

In this paper a fuzzy based Power system stabilizer is designed. The whole work is carried out in a simulation software. The proposed method is then simulated on a SMIB Energy system with FLC and conventional controller using complete state space model. The simulation results show that in the presence of small disturbances in the system, fuzzy controller is more effective compared to the conventional controller. The Fuzzy Logic Power system stabilizer gives zero steady state error and smaller overshoot and settling time than conventional power system stabilizer for a different membership function in which Gaussian membership function gives better performance.

Appendix
PARAMETER VALUES
Generator: M= 7.00 s., D = 0, Xd=1.8, Xq=1.760, Xd' =0.30, Tdo' = 7.29400, Wb=314
Exciter :(IEEE Type ST1): KA=200, TA=0.02 s.
T1=0.1540, T2=0.033, K1=0.76360; K2=0.86441; K3=0.32310; K4=1.4189; K5 = 0.1463; K6=0.41670; Ks=9.5*4.66;T_w=1.4

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