POWER SYSTEM STABILITY ENHANCEMENT USING FUZZY LOGIC BASED POWER SYSTEM STABILIZER

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Abstract

Power system is dynamic in nature and it is constantly subjected to disturbances and unpredictable faults. It's main objective that these disturbances and faults do not lead the system to unstable condition. Power system stabilizers (PSS) are used to improve the damping during low frequency oscillation and other faults under these disturbances. PSS are designed by conventional and non-conventional controllers. Conventional controller's uses phase lead compensation techniques, but they cannot provide best performance in all loading condition. To cover wide range of conditions non-conventional controllers used such as Fuzzy Logic controller. This paper presents the study about PSS using Fuzzy Logic to enhance stability of single machine infinite bus system. The input of synchronous machine are Speed deviation and acceleration. The supplementary voltage signals are taken from fuzzy logic controller are given to excitation system of the synchronous machine. Results presented in this paper shows that fuzzy logic based PSS design gives much more better performance than conventional PSS.

Keyword: single machine infinite bus system, Power System Stabilizer (PSS), Fuzzy Logic Controller (FLC)

INTRODUCTION

Power systems are dynamic in nature. they subjected to low frequency disturbance due to sudden load change and etc. that might cause loss of synchronism or an sometime it's the reason for failure of whole system. The oscillations, which are in frequency range of 0.2 to 0.3 Hz, might be generate by the disturbance in system or sometime build up spontaneously. These low frequency oscillations are generator rotor angle oscillations which limit the power capability of the system and sometime they can stop the entire system. For this reason, power system stabilizers are used to generate the supplementary control signal to damp out these low frequency oscillation (LFO). Now a days mostly conventional power system stabilizers are used to overcome this type of faults. The CPSS can be designed using classical methods such as Eigen value, root locus, and phase compensation etc. In this paper CPSS use phase compensation where the gain setting is already fixed for some situations or some specific operations but the constant changing nature of power system makes more complicated task. So it is more difficult to design a PSS that could give good performance in all operations. To solve this problem fuzzy logic based technique suggested. Using fuzzy logic based tech. mathematical model of system are not necessary, easy to improve and computationally efficient. The fuzzy logic based PSS are designed on single machine infinite bus system and compare the performance between the CPSS and FPSS. Result shows that the better performance of fuzzy logic based power system stabilizer(FLPSS) in comparison to the conventional power system stabilizer(CPSS).

SYSCHRONOUS MACHINE MODEL

The synchronous machine connected to a large system through transmission lines. Fig 1 show the configuration of SMIB. Synchronous machine connected to infinite line can be represented as the thevenin's equivalent circuit where Et is terminal voltage and Eb is bus voltage.

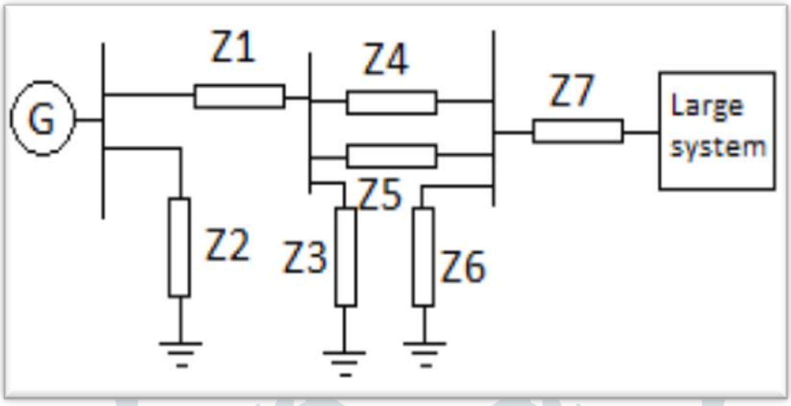


Figure 1: *General Configuration of System*

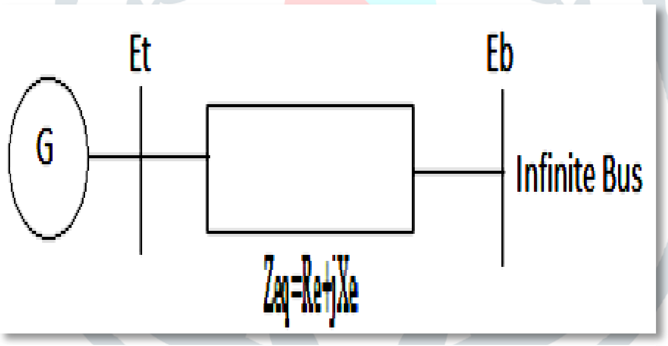


Figure 2: *Equivalent System*

CLASSICAL SYSTEM MODEL:

The generator is represented as the voltage E' behind Xd' as shown in Fig. 1.2. The magnitude of E' is assumed to remain constant at the pre-disturbance value. Let d be the angle by which E' leads the infinite bus voltage EB. The d changes with rotor oscillation. The line current is expressed as

$$I_t = \frac{E\angle 0^0 - E_B\angle -\delta}{jX_t} = \frac{E^{'} - (E_B\cos\theta - j\sin\theta)}{jX_t}$$

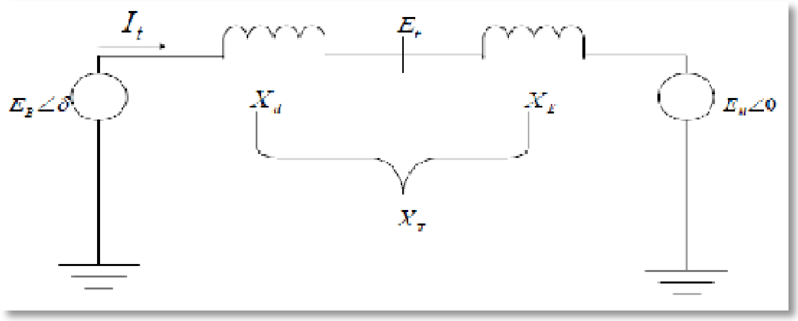


Figure 3: *Classical Model Of Generator*

$$S = P + jQ = \frac{EE_B \sin\delta}{X_t} + j\frac{E'(E' - E_B\cos\delta)}{X_t}$$

With stator resistance neglected, the air-gap power (Pe) is equal to the terminal power (P). In per unit, the air-gap torque is equal to the air gap power.

The above equation to describe small-signal performance is represented in schematic Fig. 1.3

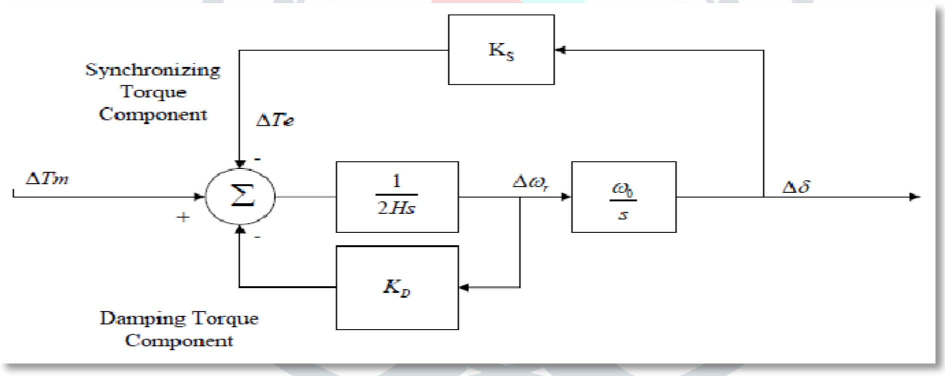


Figure 4: *Block Diagram of SMIB with Classical Model*

From the block diagram we have

$$\Delta\delta = \frac{\omega_0}{s}\left(\frac{1}{2Hs}(-K_s\Delta\delta - K_D\Delta\omega_r + \Delta T_M)\right)$$

$$= \frac{\omega_0}{s}\left(\frac{1}{2H_s}(-K_s\Delta\delta - K_D\frac{\Delta\delta}{\omega_0}s + \Delta T_M)\right)$$

Solving block diagram we get char. Equation:

$$s^2 + \frac{K_D}{2H}s + \frac{K_s\omega_0}{2H} = 0$$

Compare with general form, the undamped natural frequency and damping ratio as

$$\xi = \frac{1}{2}\frac{K_D}{\sqrt{K_s 2H\omega_0}}$$

POWER SYSTEM STABILIZER

The basic function of power system stabilizer is to add supplementary signal to the generator rotor oscillations by controlling its excitation using auxiliary stabilizing signals. Foe provide damping signal the must produce a component of electrical torque in phase with rotor speed deviations. The fig. shows the block diagram of PSS. The CPSS can use input as speed deviation of generator shaft, accelerating power or even the terminal bus frequency. In this paper the speed deviation is used as

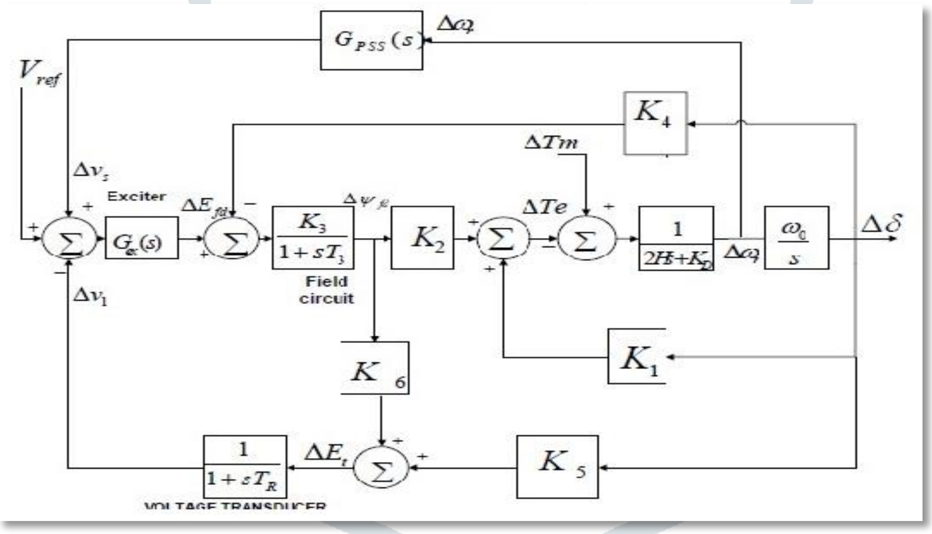


Figure 5: *Block Diagram of SMIB with PSS*

input and voltage signal as output of CPSS.

FUZZY CONTROLLER

Fuzzy logic control system are rule based system which a set of fuzzy rules present a control decision to adjust the effect of certain system simulation With the help of effective rule base we can

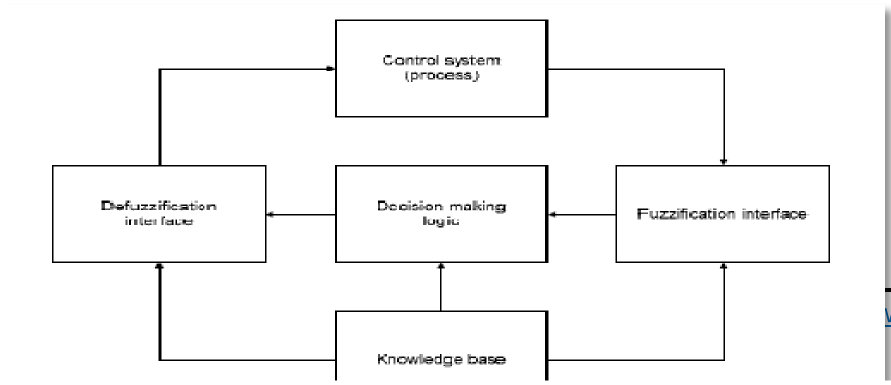


Figure 6: *Design of Fuzzy Logic Controller*

improve our system more and control also increase. The fuzzy logic controller provide an algorithm which can convert the control strategy into automatic control strategy. Fig. shows the fuzzy logic controller which consists of a fuzzification interface, a knowledge base, control system, decision making logic. And a defuzzification interface.

SIMULATION AND RESULTS

The performance of SMIB has been studied

(1) With excitation system

(2) With conventional PSS

(3) With fuzzy logic based power system stabilizer

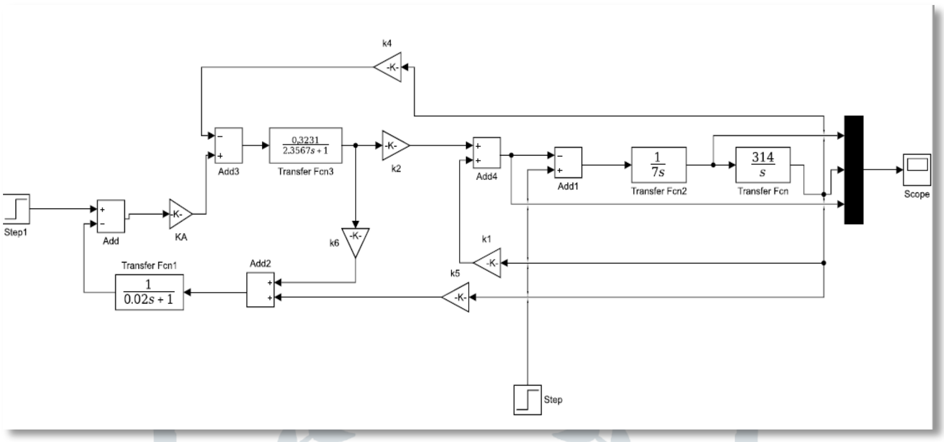
The data taken from:

Parameters	Numerical value
P	0.9
Q	0.3
Et	1.0
F	50
Xd	1.81
Xq	1.76
Xd1	0.3
XL	0
Xe	0.65
Ra	0.003
Td01	8.0
H	3.5
Ω_0	314
K_D	0
T_R	0.02
E_{Tmag}	1.0
L_{adu}	1.65
L_{adu}	1.60
R_{fd}	0.0006
L_{fd}	0.153
K_{sd}	0.8491
K_{sq}	0.8491
K_{sdI}	0.434
K_{sdI}	0.434
A_{SAT}	0.031
B_{SAT}	6.93
Ψ_1	0.8

Frequency of oscillation	10

With excitation system

The model used in the Simulink is shown in the fig. In this paper the term K is constant. And the value of K calculated by using above parameters:



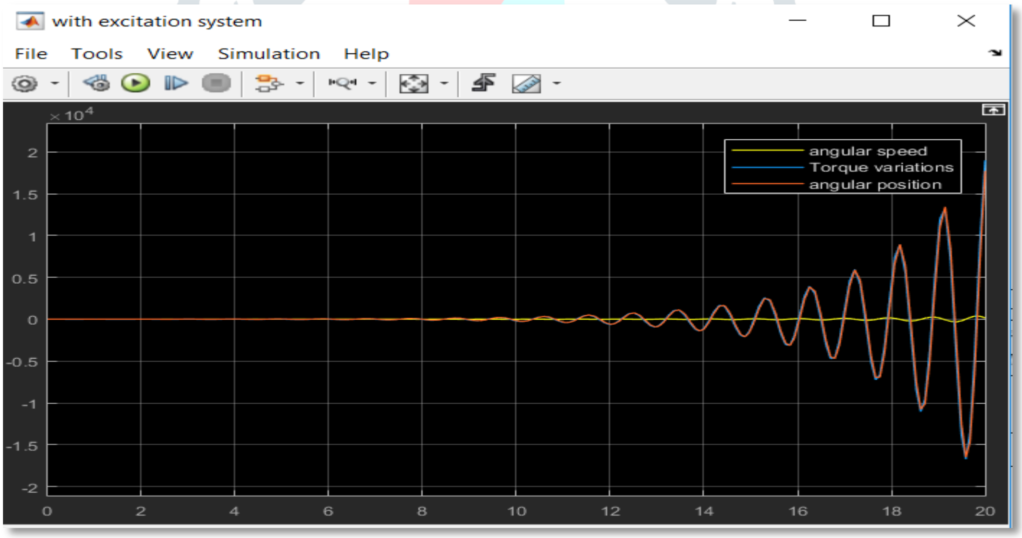


Figure 7: *SMIB with AVR Only*

$$K_1 = 0.7635, K_2 = 0.8643, K_3 = 0.3230, K_4 = 1.4188$$

With conventional power system stabilizer (CPSS)

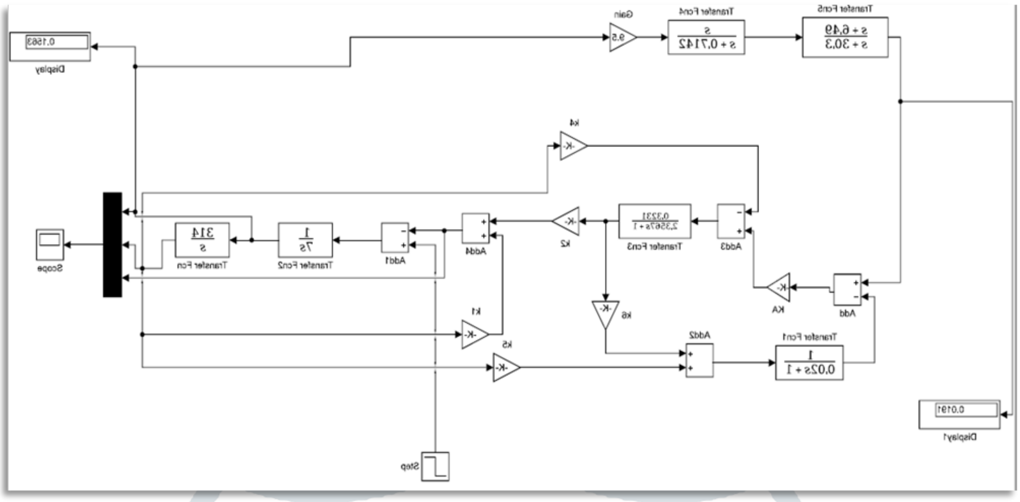


Figure 8: *SMIB with AVR and PSS*

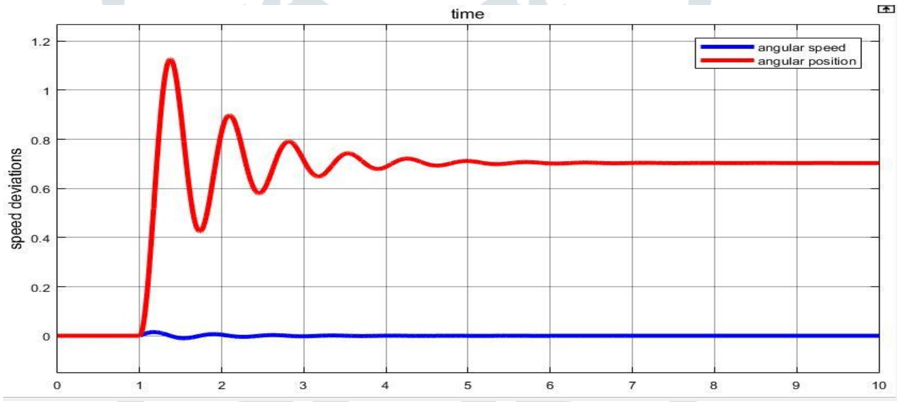
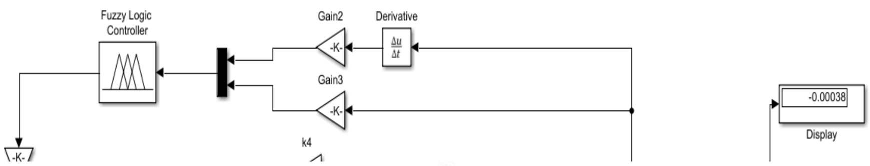


Figure 9: *variation of angular speed, angular position and torque when PSS is applied with K5 negative*

With fuzzy logic based power system stabilizer



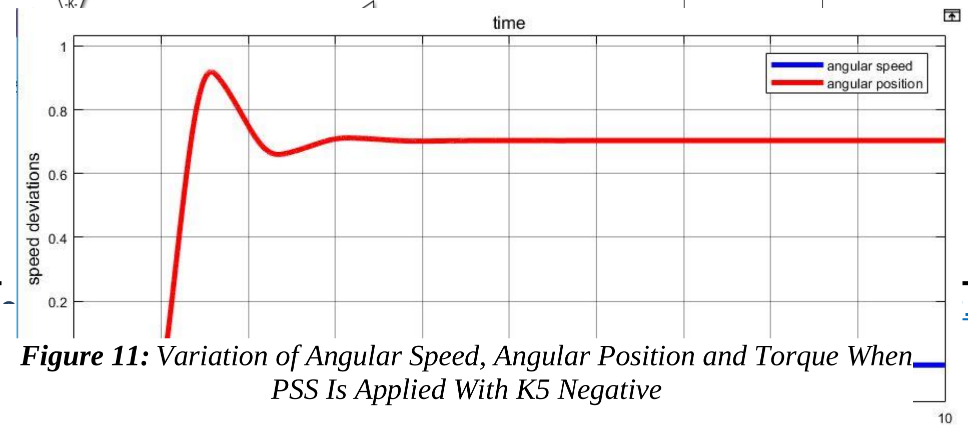


Figure 11: *Variation of Angular Speed, Angular Position and Torque When PSS Is Applied With K5 Negative*

CONCLUSION

In this paper work is carried out to damp out the oscillation of the power system using fuzzy logic based controller on a single machine infinite bus system. FLPSS shows that superior performance than the power system stabilizer in term of settling time and damping effect. So, we can conclude that the performance of FLPSS is better than conventional power system stabilizer**.**

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