Comparative Study between PI, PD PID and Fuzzy Controllers & PSS

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Abstract— Power system stabilizer (PSS) based on four controllers were implemented on a single machine infinite bus system for attaining stability. Four controllers used were PI, PD, PID and Fuzzy. Then a comparison study was done with the above controllers. These results were simulated in MATLAB. Each controller has its own advantages and disadvantages. The comparative study was done for speed deviations, load angle deviations and terminal Voltage deviations. Different types of controllers like Proportional-plus derivative (PD), Proportional-plus-integral (PI), Proportional-plus-derivative-plus-integral (PID) and Fuzzy Controllers were designed to stabilize the system.

Key words: Power System Stabilizer, PI, PD, PID, Fuzzy Logic, Simulink

I. Introduction

Power system stability is the tendency of a power system to develop restoring forces equal to or greater than the disturbing forces to maintain the state of equilibrium. Since power systems rely on synchronous machines for generation of electrical power, a necessary condition for satisfactory system operation is that all synchronous machines remain in synchronism. This aspect of stability is influenced by the dynamics of generator rotor angles and power-angle relationships.

The power system is a dynamic system. The electrical power systems today are no longer operated as isolated systems, but as interconnected systems which may include thousands of electric elements and be spread over vast geographical areas. There are many advantages of interconnected power systems.

- Provide large blocks of power and increase reliability of the system.
- Reduce the number of machines which are required both for operation at peak load and required as spinning reserve to take care of a sudden change of load.
- Provide economical source of power to consumers.

On the other hand there are disadvantages of using interconnected power systems. The interconnecting ties between neighboring power systems are relatively weak when compared to the connections within the system. It easily leads to low frequency inter oscillation. Many of the early instances of oscillation instability occur at low frequencies when interconnections are made.

II. Various controller

A. PI Controller

Figure 1 shows the block diagram of PSS based PI controller. Proportional-plus-integral controller consist of two terms producing an output which one is proportional to the input signal and other proportional to the integral of input signal. It improves the relative stability and steady state tracking accuracy.

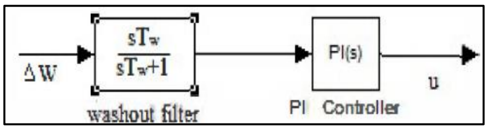

Fig. 1: PSS based PI controller

B. PD Controller

Proportional-plus-derivative controller produces an output which consists of two terms, where one is proportional to input signal and other proportional to the derivative of input signal. The PD controller increases the damping of the system which results in reducing the peak overshoot. Figure 2 shows the block diagram of PSS based PD controller.

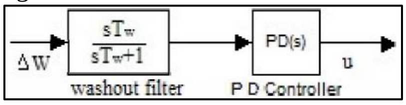

Fig. 2: PSS based PD controller

C. PID Controller

PID controller stabilizes the gain, reduces the steady state error and peak overshoot of the system. Figure 3 shows the block diagram of PSS based PID controller.

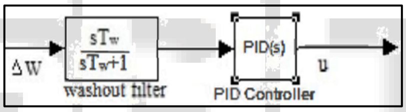

Fig. 3: PSS based PID stabilizer

D. Fuzzy Controller

A simple fuzzy controller based on the experience can damp only local modes. To damp both local and inter-area modes of oscillation, the experience is difficult to be obtained. So, the design process needs a systematic method for obtaining the rule base and the domain ranges. The proposed solution of this problem is that is a fuzzy controller is to be developed based on the optimal control theory [4]. This is capable to obtain a near optimal fuzzy controller that is characterized by its systematic nature in design.

- Fuzzification module – the functions of which are first, to read, measure, and scale the control variable (speed, acceleration) and, second, to transform the measured numerical values to the corresponding linguistic (fuzzy variables with appropriate membership values);
- Knowledge base - this includes the definitions of the fuzzy membership functions defined for each control variables and the necessary rules that specify the control goals using linguistic variables;
- Inference mechanism – it should be capable of simulating human decision making and influencing the control actions based on fuzzy logic;
- Defuzzification module – which converts the inferred decision from the linguistic variables back the numerical values.

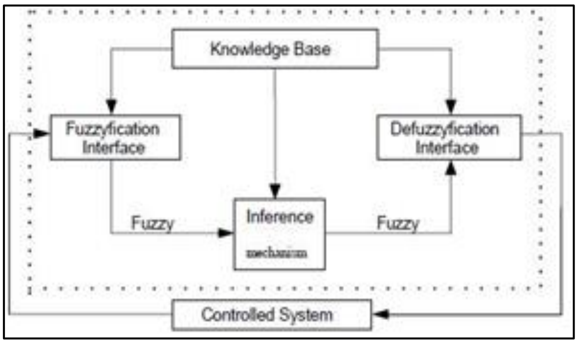

Fig. 4: Schematic diagram of the FLC building blocks

E. Simulink Models of SMIB System with Different PSS Structure

1) PI-PSS

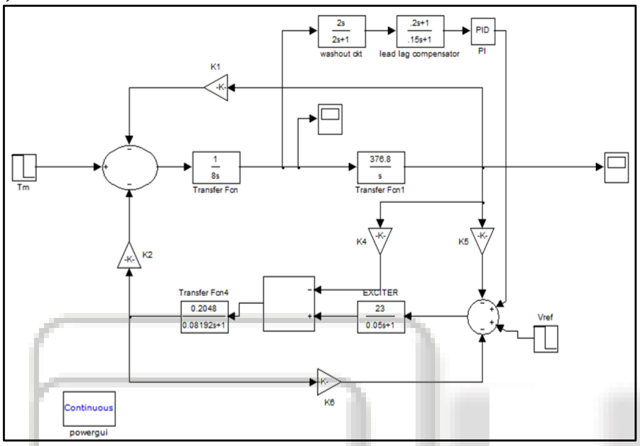

Fig. 5: Simulink model of SMIB system with PI-PSS

2) PD-PSS

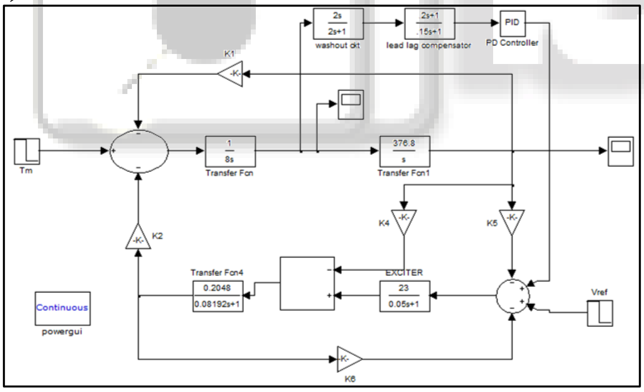

Fig. 6: Simulink model of SMIB system with PD-PSS

3) PID-PSS

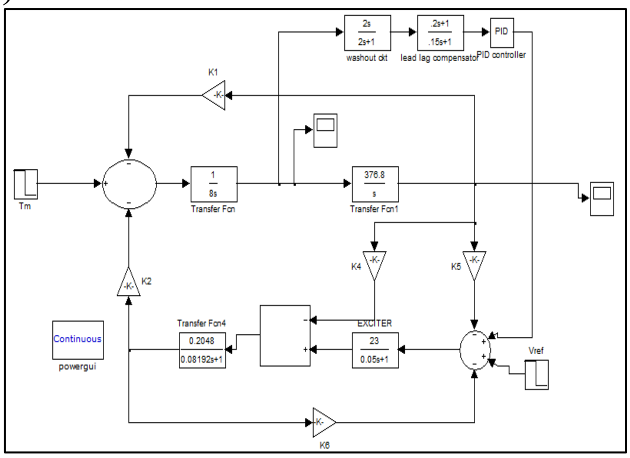

Fig. 7: Simulink model of SMIB system with PID-PSS

F. Fuzzy Controller Power System Stabilizer

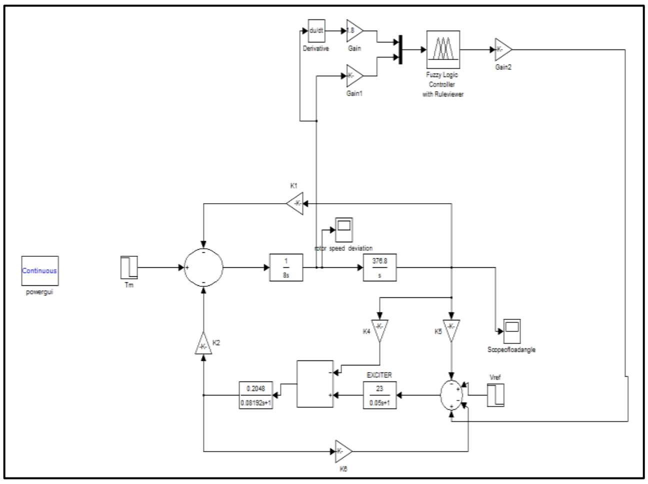

Fig. 8: Simulink model of SMIB system with Fuzzy Controller based PSS

G. Output Waveforms of Different PSS Structures

1) PI-PSS

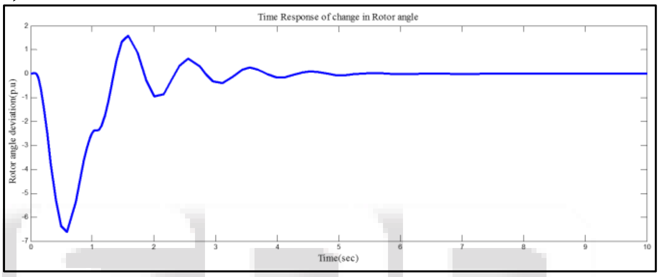

Fig. 9: Time Response of change in Rotor angle in PI

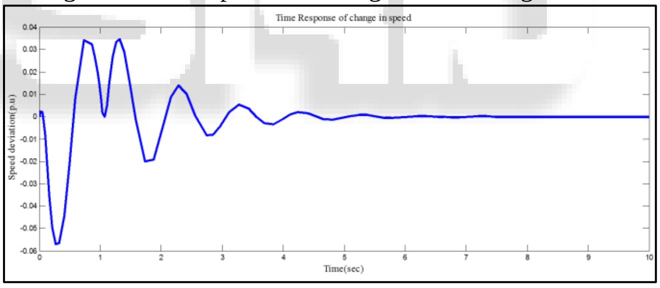

Fig. 10: Time Response of change in Speed in PI

2) PD-PSS

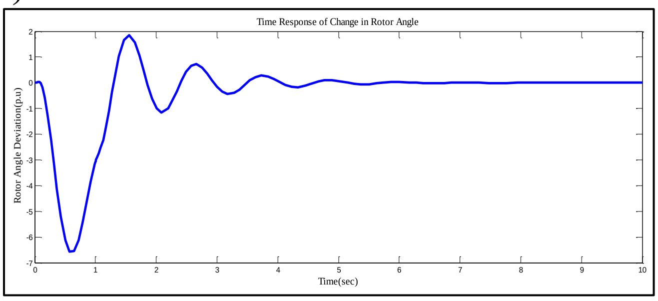

Fig. 11: Time Response of change in Rotor angle in PD

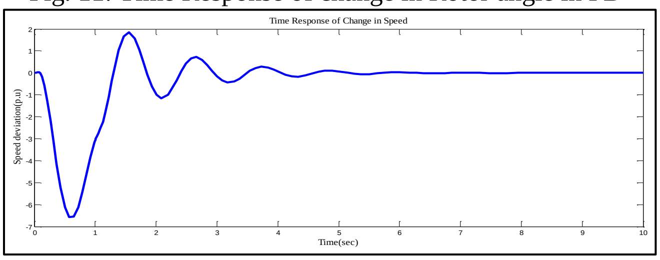

Fig. 12: Time Response of change in Speed in PD

3) PID-PSS

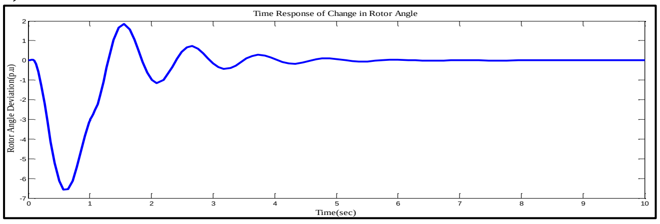

Fig. 13: Time Response of change in Rotor angle in PID

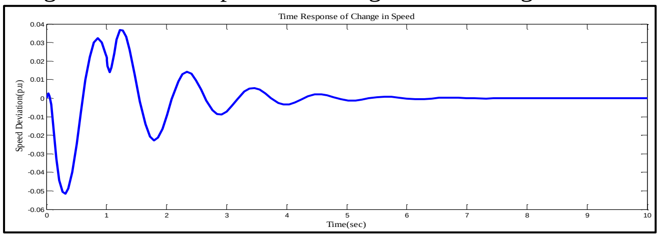

Fig. 14: Time Response of change in Speed in PID

H. Fuzzy Based controller for PSS

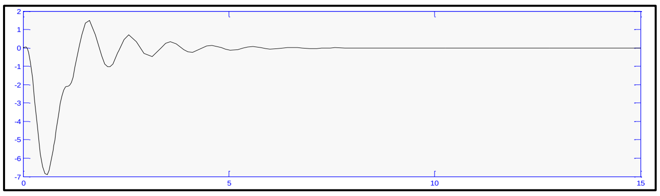

Fig. 15: Time Response of change in Rotor angle in Fuzzy

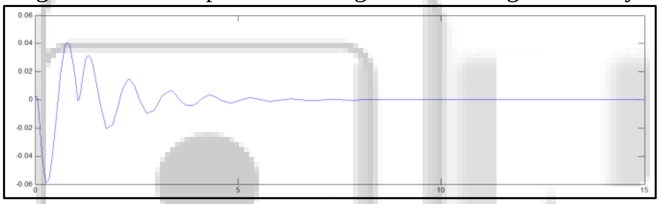

Fig. 16: Time Response of change in Speed in fuzzy

III. CONCLUSIONS

We can conclude that in SMIB system with PSS, Small signal stability gets increased due to increased damping torque. Various Structures for PSS are used in such as PI-PSS, PD-PSS, PID-PSS & Fuzzy controller based power system. Each structure takes auxiliary input signal of $\Delta\varpi$, angular speed deviation, and gives output Δv_s .

PI gives the relative stability; the system is undamped in case. Whereas PD gives the system output with an undamped, but combination of PI & PD gives the PID Controller.

PD-PSS gives better stability than PI-PSS. PID-PSS gives better result than PI-PSS & PD-PSS. BUT Fuzzy controller gives better results than PID-PSS, PD-PSS & PI-PSS and so on. Among all structures we have used, FUZZY controller gives the best result.

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