[Singh, 4(4): April 2017] ISSN 2348 – 8034
DOI-10.5281/zenodo.1143959 Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

FUZZY LOGIC POWER SYSTEM STABILIZER FOR IMPROVEMENT OF DYNAMIC PERFORMANCE OF MACHINE

Ramandeep Singh[*1] & Somit Dheer[2]

[*1]Assistant Professor, Department of Electrical Engineering, Ferozepur College of Engineering and Technology, Ferozeshah, Punjab, India

[2]Assistant Professor, Department of Electrical Engineering, GTBKIET, Chhapianwali, Malout, Punjab, India

ABSTRACT

Small signal stability is the ability of the power system to maintain synchronism under small perturbations. The small signal dynamic stability of electric power system has been the subject of major theoretical and practical interest and it continue to grow in importance as the control requirements of the power plants become more sophisticated and demanding torque. The range of 0.2 to 2.5 Hz. the damping characteristics of synchronous machine's rotor oscillations is a function of system structures, operating condition and control structures. The power system stabilizers are widely used to damp out low frequency oscillations. Also, the optimum application of stabilizer is well defined and straightforward in cases where the instability is clearly identified with a machine or a group of machines. However, in more general case of widespread oscillation permeating a large interconnection, the identification of optimum sites for stabilizer application is complicated. Hence, in view of the potentially high costs of applying stabilizers to older machines, it is vital that the relative effectiveness of stabilizers at all system locations be studied and PSS be applied or provided at all new machines and retrofitted only to those older machines where they are essential for satisfactory system damping. In our example we will use the Participation factor and Sensitivity method for PSS location. According to Participation method which machine has the highest value of participation factor will be best suited for PSS location. According to Sensitivity method PSS will be located at that machine which has the highest value of Sensitivity factor.

Keywords- *Small Signal Stability, Participation Factor Stability (PSS), Sensitivity method.*

I. INTRODUCTION

Small signal stability is the ability of the power system to maintain synchronism under small perturbations. The small signal dynamic stability of electric power system has been the subject of major theoretical and practical interest and it continue to grow in importance as the control requirements of the power plants become more sophisticated and demanding [1-3]. The disturbances occur continually in a power system because of variations in the load and generation. The disturbances are considered sufficiently small for Linearization of system equations to be permissible, for purposes of analysis. Small signal instability that may result can be of two forms [4-6].

(i) Steady increase in rotor angle due to lack of sufficient synchronizing torque.
(ii) Rotor oscillations of increasing amplitude due to lack of sufficient damping torque.

The low frequency rotor oscillations, also called the electromechanical models are in the range of 0.2 to 2.5 Hz. the damping characteristics of synchronous machine's rotor oscillations is a function of system structures, operating condition and control structures. The power system stabilizers are widely used to damp out low frequency oscillations [7,8]. Eigen value analysis has become the main tool for the study of this type of power system stability problem In many case, the system is approximated for design purpose by single machine tied to an infinite bus, which cannot reflect the interaction between machines e.g. inter area modes. As such a linear model of multi-machine system is sought this does less approximation and more or less replicates the actual system [9-11].

Also, the optimum application of stabilizer is well defined and straightforward in cases where the instability is clearly identified with a machine or a group of machines. However, in more general case of widespread oscillation permeating a large interconnection, the identification of optimum sites for stabilizer application is complicated. To be effective the stabilizer must be applied to machine that is both near antinodes of the slightly damped modes of oscillations and connected via low enough transfer impedances to induce strong damping torque in the surrounding machines [12]. Experience with the stabilizer application is rapidly developing but geographically loose interconnections have shown that the straight forward course of applying stabilizers at all new plants can be ineffective because these machines are not necessarily located at best points for damping of troublesome modes of oscillations [13-17]. Hence, in view of the potentially high costs of applying stabilizers to older machines, it is vital that the relative effectiveness of stabilizers at all system locations be studied and PSS be applied or provided at all new machines and retrofitted only to those older machines where they are essential for satisfactory system damping[19, 21].

II. POWER SYSTEM STABILIZER

Power system Stabilizer (PSS) have extensively been used in modern power system for enhancing stability of the system. The PSS extend system stability limits by modulating generator excitation to provide damping to the oscillations of the synchronous machine rotor with respect to one another. The conventional PSS introduced nearly five decades ago, comprising a cascade lead-lag network with rotor speed deviation as input signal has made great contributions in enhancing stability of the system. The conventional fixed structure PSS, design using a liberalized provides optimum performance for a nominal set of operating and system parameters. However, the performance becomes sub optimal following variations in the system parameters and loading conditions from their nominal values.

The block diagram of the PSS used in industry is shown in Figure 2.1. It consists of a washout circuit, dynamic compensator, torsional filter and limiter. The function of each of the components of PSS with guidelines for the selection of parameters (tuning) are given next.

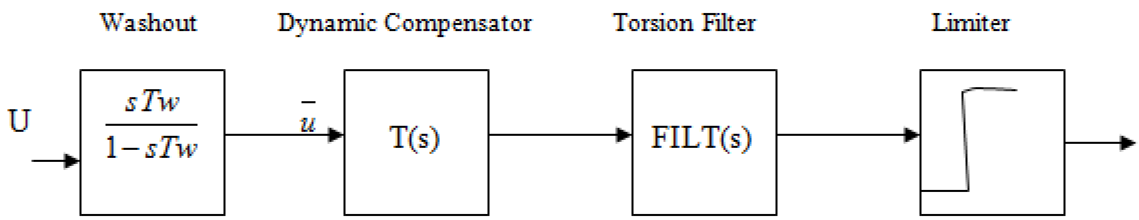

Figure 1. Block Diagram of PSS

It is to be noted that the major objective of providing PSS is to increase the power transfer in the network, which would otherwise be limited by oscillatory instability. The PSS must also function properly when the system is subjected to large disturbances

Washout Circuit

The washout circuit essentially as a high pass filter and it must pass all frequencies that are of interest. If only the local modes are of interest, the time constant T_w can be chosen in the range of 1 to 2.However, if inter area modes are also to be damped, then T_w must be chosen in the range of 10 to 20.A resent study [4] has shown that a value of T_w=10 is necessary to improve damping of the inter area modes. There is also a noticeable improvement in the first swing stability when T_w is increased from 1.5 to 10. The higher value of T_w also improved the overall terminal voltage response during system islanding conditions.

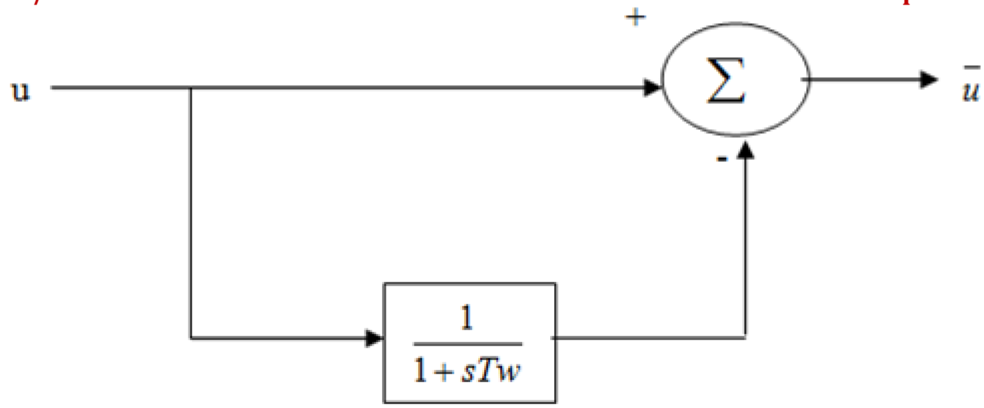

Figure 2. Washout Circuit

Phase Compensator

The phase compensation block provides the appropriate phase-lead characteristic to compensate for the phase lag between the exciter input and generator electrical (air-gap) torque.

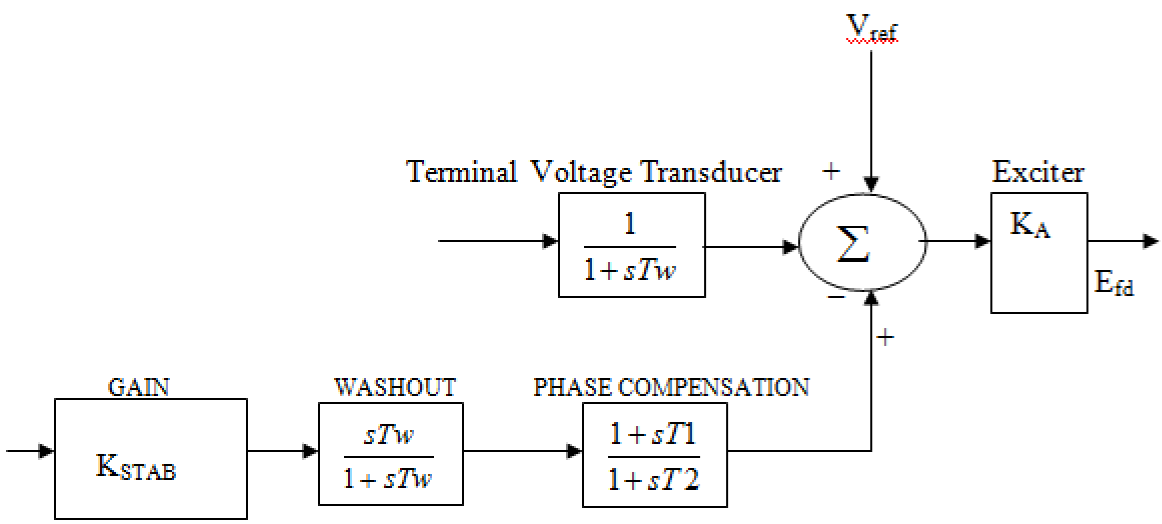

Figure 3. Thyristor Exciter System with AVR and PSS

III. RESULTS AND DISCUSSION

Dynamic performance of the system with FLPSS is first examined considering the linear model.· The FLPSS operator in discrete mode. FLPSS output u is computed during each integrations step while solving the state equations using Rungta-Kutta technique.

$$\dot{X} = AX + Bu + \Gamma p$$

Where, $$A = \begin{bmatrix} -\frac{K_D}{2H} & -\frac{K_1}{2H} & -\frac{K_2}{2H} & 0 \\ 2\pi f_0 & 0 & 0 & 0 \\ 0 & -\frac{K_3 K_4}{T_3} & -\frac{1}{T_3} & -\frac{K_3 K_A}{T_3} \\ 0 & -\frac{K_5}{T_R} & K_6 T_R & 0 \end{bmatrix}$$

$$B = \begin{bmatrix} 0 \\ 0 \\ \frac{K_3 K_A}{T_3} \\ 0 \end{bmatrix} \qquad X = \begin{bmatrix} \Delta\dot{\omega} \\ \Delta\dot{\delta} \\ \Delta\dot{\psi}_{fd} \\ \Delta v_1 \end{bmatrix}$$

$$X = \begin{bmatrix} \Delta\dot{\omega} \\ \Delta\dot{\delta} \\ \Delta\dot{\psi}_{fd} \\ \Delta v_1 \end{bmatrix}$$

$$\Gamma = \begin{bmatrix} \frac{1}{2H} & 0 \\ 0 & 0 \\ 0 & \frac{K_3 K_A}{T_3} \\ 0 & 0 \end{bmatrix}$$

$$p = \begin{bmatrix} \Delta T_m \\ \Delta v_{ref} \end{bmatrix}$$

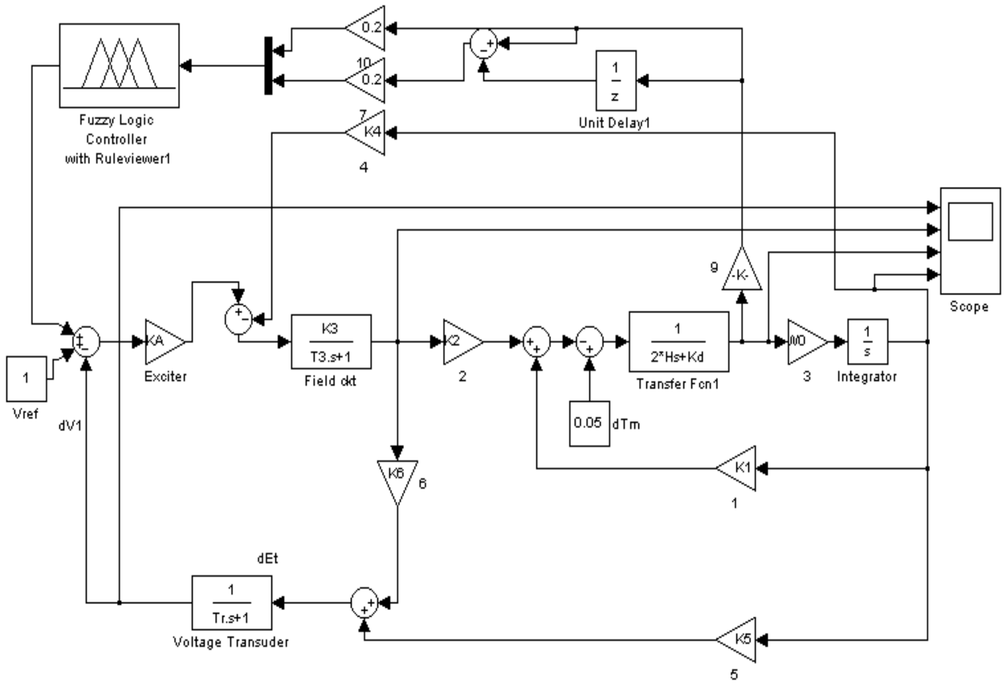

Figure 4. System Model with Fuzzy Based PSS

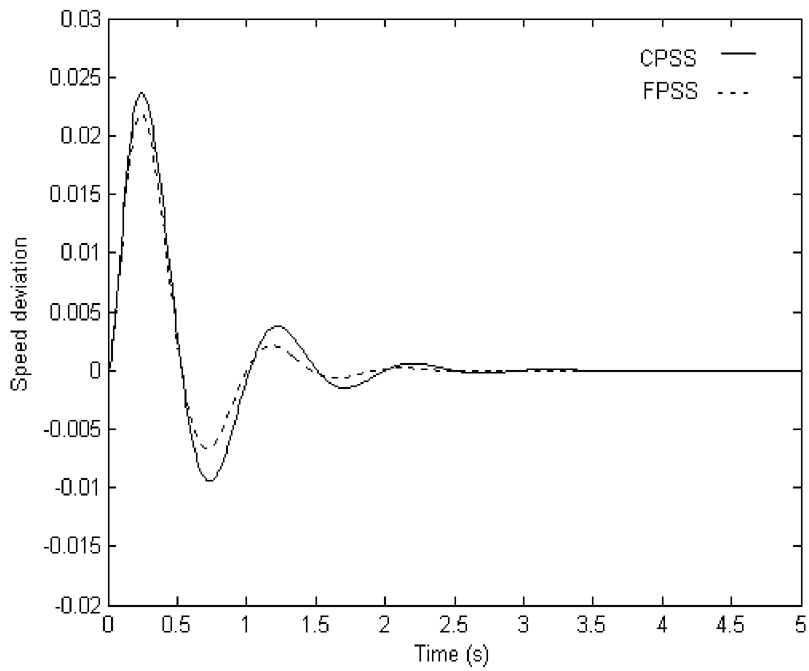

Figure.5 Variation of speed deviation with time

ISSN 2348 – 8034
Impact Factor- 4.022

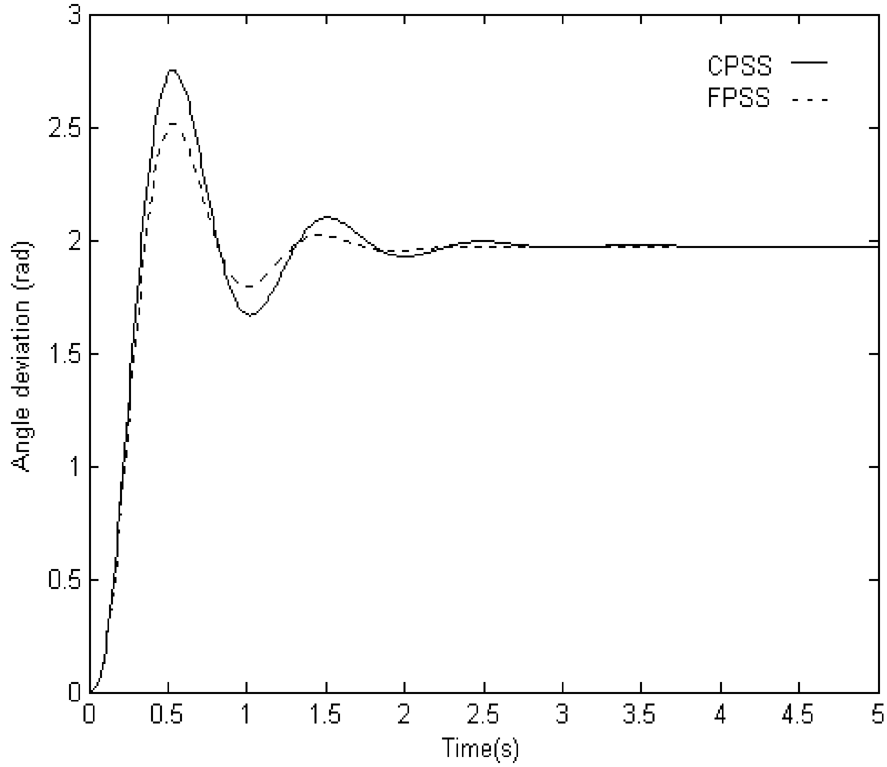

Figure 6. Variation of Angle Deviation with Time

It is clearly that J obtained with FLPSS hardly differs from that with conventional PSS, whereas the peak overshoot also remains almost the same. However, the settling time falls by nearly 25%.

IV. CONCLUSION

Power systems are subjected to low frequency disturbances that might cause loss of synchronism and an eventual breakdown of entire system. The oscillations, which are typically in the frequency range of 0.2 to 3.0 Hz, might be excited by the disturbances in the system or, in some cases, might even build up spontaneously. These oscillations limit the power transmission capability of a network and, sometimes, even cause a loss of synchronism and an eventual breakdown of the entire system. For this purpose, Power system stabilizers (PSS) are used to generate supplementary control signals for the excitation system in order to damp these low frequency power system oscillations. The use of power system stabilizers has become very common in operation of large electric power systems.

In this thesis work initially the effectiveness of power system stabilizer in damping power system stabilizer is reviewed. Then the fuzzy logic based power system stabilizer is introduced by taking speed deviation and acceleration of synchronous generator as the input signals to the fuzzy controller and voltage as the output signal. FLPSS shows the better control performance than power system stabilizer in terms of settling time and damping effect. Therefore, it can be concluded that the performance of FLPSS is better than conventional PSS. However, the choice of membership functions has an important bearing on the damping of oscillations. From the simulation studies it shows that the oscillations are more pronounced in case of trapezoidal membership functions. The response with gaussian member-ship functions is comparable to triangular membership functions. However, the performance of FLPSS with triangular membership functions is superior compared to other membership functions.

[Singh, 4(4): April 2017] ISSN 2348 – 8034
DOI-10.5281/zenodo.1143959 Impact Factor- 4.022

REFERENCES

1. P. Kundur., \Power system control and stability," New York: McGraw-Hill, vol. PAS-88, pp. 1103{1166,1994.}
2. D. Chaturvedi, O. Malik, and P. Kalra, \Experimental studies with a generalized neuron-based power system stabilizer," Power Systems, IEEE Transactions on, vol. 19, no. 3, pp. 1445 { 1453, aug. 2004.}
3. P. M. Anderson, A. A. Fouad, and H. H. Happ, \Power system control and stability," Systems, Man and Cybernetics, IEEE Transactions on, vol. 9, no. 2, p. 103, feb. 1979.
4. W.-C. Chan and Y.-Y. Hsu, \An optimal variable structure stabilizer for power system stabilization," Power Apparatus and Systems, IEEE Transactions on, vol. PAS-102, no. 6, pp. 1738 {1746, june 1983.}
5. C.-J. Chen, T.-C. Chen, H.-J. Ho, and C.-C. Ou, \Pss design using adaptive recurrent neural network controller," in Natural Computation, 2009. ICNC '09. Fifth International Conference on, vol. 2, aug. 2009, pp. 277 {281.
6. W.Chi-Jui and H. Yuan-Yih, \Design of self-tuning pid power system stabilizer for multimachine power systems," Power Systems, IEEE Transactions on, vol. 3, no. 3, pp. 1059 {1064, aug 1988.
7. F. Demello and C. Concordia, \Concepts of synchronous machine stability as a®ected by excitation control," Power Apparatus and Systems, IEEE Transactions on, vol. PAS-88, no. 4, pp. 316 {329, april 1969.
8. M. Kothari and T. Kumar, \A new approach for designing fuzzy logic power system stabilizer," in Power Engineering Conference, 2007. IPEC 2007. International, dec. 2007, pp. 419 {424.
9. K. R. Padiyar, \Power system dynamics: Stability and control," in printed in the Republic of Singapore, ISBN: 0-471-19002-0, 1996.
10. A. Al-Hinai, \Dynamic stability enhancement using genetic algorithm power system stabilizer," in Power System Technology (POWERCON), 2010 International Conference on, oct. 2010, pp. 1 {7.
11. K. Al-Olimat, A. Farhoud, and J. Hurtig, \Power system stabilizers with fuzzy logic switching," in Power Systems Conference and Exposition, 2006. PSCE '06. 2006 IEEE PES, 29 2006-nov. 1 2006, pp. 2152 {2157.
12. M. Dobrescu and I. Kamwa, \A new fuzzy logic power system stabilizer performances," in Power Systems Conference and Exposition, 2004. IEEE PES, oct. 2004, pp. 1056 { 1061 vol.2.}
13. S. Gupta, N; Jain, \Comparative analysis of fuzzy power system stabilizer using di®erent membership functions,," International Journal of Computer and Electrical Engineering, vol. 2, no. 2, april. 2010.
14. G.-H. Hwang, J.-H. Park, H. T. Kang, and S. Kim, \Design of fuzzy power system stabilizer using adaptive evolutionary algorithm," in Industrial Electronics, 2000. ISIE 2000. Proceedings of the 2000 IEEE International Symposium on, vol. 1, 2000, pp. 42 {47 vol.1}.
15. Y. Lin, \Systematic approach for the design of a fuzzy power system stabiliser," in Power System Technology, 2004. PowerCon 2004. 2004 International Conference on, vol. 1, nov. 2004, pp. 747 { 752 Vol.1}.
16. J. Lu, M. Nehrir, and D. Pierre, \A fuzzy logic-based adaptive power system stabilizer for multi-machine systems," in Power Engineering Society Summer Meeting, 2000. IEEE, vol. 1, 2000, pp. 111 {115 vol. 1}.
17. F. M. H. M. Saidy, \Performance improvement of a conventional power system stabilizer," International Journal of Electrical Power and Energy Systems, vol. 150, no. 5, pp. 313{323, oct. 2005.
18. N. Nallathambi and P. Neelakantan, \Fuzzy logic based power system stabilizer," in E-Tech 2004, july 2004, pp. 68 { 73}.
19. K. R. Padiyar, \Power system dynamics: Stability and control," in printed in the Republic of Singapore, ISBN: 0-471-19002-0, 1996.
20. A. E. T. Hussein, M.S. Saad and A. Bahgat, \Robust adaptive fuzzy logic power system stabilizer," An International Journal, vol. 36, no. 10, dec. 2009.
21. J. Van Ness, F. Brasch, G. Landgren, and S. Naumann, \Analytical investigation of dynamic instability occuring at powerton station," Power Apparatus and Systems, IEEE Transactions on, vol. PAS-99, no. 4, pp. 1386 {1395, july 1980.}