IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 9, Issue 3 Ver. I (May – Jun. 2014), PP 42-49
www.iosrjournals.org

Performance Of Power System Stabilizerusing Fuzzy Logic Controller

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Abstract: *Power system stabilizers (PSS) must be capable of providing appropriate stabilization signals over a broad range of operating conditions and disturbances. Traditional PSS rely on robust linear design methods. In an attempt to cover a wide range of operating conditions, expert or rule based controllers have been proposed. Recently, fuzzy logic as a novel robust control design method has shown promising results. In this paper a fuzzy logic based power system stabilizer for stability enhancement of a two-area four machine system are designed. In order to accomplish the stability enhancement, speed deviation ($\Delta\omega$) and active power deviation (ΔP) of the rotor synchronous generator were taken as the inputs to the fuzzy logic controller. These variables take significant effects on damping the generator shaft mechanical oscillations. The stabilizing signals were computed using fuzzy membership function depending on these variables. The performance of the system with fuzzy logic PSS is compared with the conventional PSS and the system without PSS.*

Keywords: Power system stabilizer, fuzzy logic, stability.

I. Introduction

Power system stability may be broadly defined **as** that property of a power system that enables it to remain in **a** state of operating equilibrium under normal operating conditions and to regain an acceptable state of equilibrium after being subjected to **a** disturbance [1]. Traditionally, the stability problem has been one of the maintaining synchronous operations. 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 or, Colloquially, "in-step". This aspect of stability is influenced by the dynamics of generator rotor angle and power-angle relationships. Instability may also be encountered without loss of synchronism [3]. For example, a system consisting of a synchronous generator feeding an induction motor load through **a** transmission line can become unstable because of the collapse of load voltage. Maintenance of synchronism is not an issue in this instance instead; the concern is stability and control of voltage. An effective way to meet the conflicting exciter performance requirements with regard to system stability is to provide a power system stabilizer. The conventional power system stabilizers work well at the particular network configuration and steady state conditions for which they were designed. Once conditions change the performance degrades. This can be overcome by an intelligent non-linear PSS based on fuzzy logic. Such a fuzzy logic power system stabilizer is developed, using speed and power deviation. As inputs and provide an auxiliary signal for the excitation system of a synchronous motor. In this thesis, the FLPSS's effect on the system damping is then compared with a conventional PSS and without PSS.

II. Conventional Pss

The earliest PSS developed is called conventional PSS (CPSS). It is based on the transfer function designed using the classical control theory [2]. It uses a lead-lag compensation network to compensate for the phase shift caused by the low frequency oscillation of the system during perturbations. By approximately tuning the parameters of a lead-lag compensation network, it is possible to make a system have desired damping ability. However, power systems are highly non linear systems. The linear fed system models used to design conventional power system stabilizers are valid only at the operating point that is used to linear fed the system. As a fixed parameter controller, CPSS cannot provide optimal performance under very wide operating conditions [4]. The commonly used input signals to the PSS are shaft speed, integral of power and terminal frequency. Depending upon the nature of the input the PSS's are classified as follows.

- Delta-omega PSS
- Delta-P-omega PSS
- Frequency-based PSS

III. Fuzzy Logic Controller

3.1 Introduction

Fuzzy logic is a derivative from classical Boolean logic and implements soft .linguistic variables on **a** continuous range of truth values to be defined between conventional binary. It can often be considered a suspect of conventional set theory [5]. Since fuzzy logic handles approximate information in **a** systematic way, it is ideal for controlling non-linear systems and for modeling complex systems where an inexact model exists or systems where ambiguity or vagueness is common. **A** typical fuzzy system consists of **a** rule base, membership functions and an inference procedure PI. Fuzzy logic is **a** superset of conventional Boolean logic that has been extended to handle the concept of partial truth-truth-values between "completely true" and "completely false".

3.2 Fuzzy subsets

Just as there is a strong relationship between Boolean logic and the concept of a subset, there is a similar strong relationship between fuzzy logic and fuzzy subset theory [10]. In classical set theory, a subset U of asset S can be defined as a mapping from the elements of S to the elements the subset {0, 1},

$$U: S \longrightarrow \{0, 1\}$$

The mapping may be represented as a set of ordered pairs, with exactly one ordered pair present for each element of S. The first element of the ordered pair is an element of the set S, and the second element is an element of the set {0,1}. The value zero is used to represent non-membership, and the value one is used to represent complete membership. The truth or falsity of the statement '**X** is in **U**'is determined by finding the ordered pair whose first element is X. The statement is true if the second element of the ordered pair is 1, and the statement is false if it is 0.

3.3 Design procedure

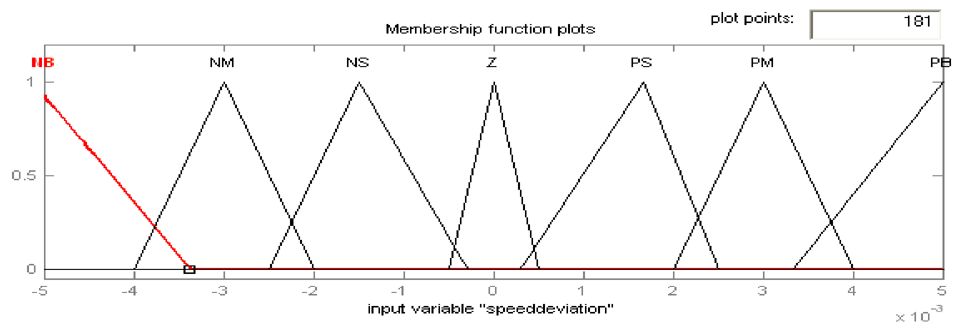
The fuzzy logic controller (FLC) design consists of the following steps [5].

1. Identification of input and output variables.
2. Construction of control rules.
3. Establishing the approach for describing system state in terms of fuzzy sets, i.e., establishing fuzzification method and fuzzy membership functions.
4. Selection of the compositional rule of inference.
5. Defuzzification method, i.e., transformation of the fuzzy control statement into specific control actions.

Steps 1 and 2 are application specific and typically straightforward. There are several approaches to Steps 4 and 5 but most of the literature reports using minimum implication and center-of-gravity defuzzification. The design methodology in this tutorial centers on forming general rule membership functions and then determining parameters based on observed response to a disturbance.

3.4 Membership function

The linguistic variables chosen for this controller are speed deviation, active power deviation and voltage. In this, the speed deviation and active power deviation are the input linguistic variables and voltage is the output linguistic variable. Each of the input and output fuzzy variables is assigned seven linguistic fuzzy subsets varying from negative big (NB) to positive big (PB). Each subset is associated with a triangular membership function to form a set of seven membership functions for each fuzzy variable. The membership function for each linguistic variable is as follows.



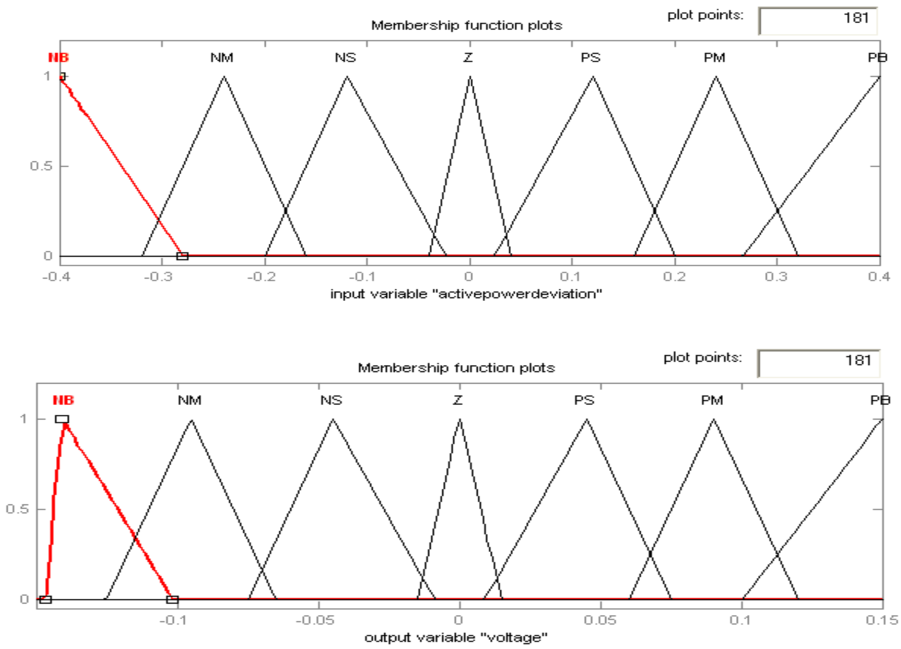


Figure1. Membership function of the linguistic variables

3.5 Fuzzy rule base

The linguistic terms chosen for this controller are seven. They are negative large (NL), negative medium (NM), negative small (NS), zero (Z), positive small (PS), positive medium (PM) and positive large (PL). After assigning the input, output ranges to define fuzzy sets, mapping each of the possible seven input fuzzy values of speed deviation, active power deviation to the seven output fuzzy values is done through a rule base. Thus the fuzzy associative memory (FAM) comes into picture. The rules are framed keeping in mind the nature of the system performance and the common sense. The rules are as follows:

Speed Deviation	Active power deviation						
	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	Z
NM	NB	NB	NM	NM	NS	Z	PS
NS	NB	NM	NM	NS	Z	PS	PM
Z	NM	NM	NS	Z	PS	PM	PM
PS	NM	NS	Z	PS	PM	PM	PB
PM	NS	Z	PS	PM	PM	PB	PB
PB	Z	PS	PM	PB	PB	PB	PB

Table 1 Fuzzy Associate Memory (FAM) Table

IV. Test System

The test system consists of two fully symmetrical areas linked together by two 230 kV lines of 220 km length. It was specifically designed in to study low frequency electromechanical oscillations in large interconnected power systems. Each area is equipped with two identical round rotor generators rated 20 kV/900 MVA. The synchronous machines have identical parameters, except for inertias which are H = 6.5s in area 1 and H = 6.175s in area 2. The load is represented as constant impedances and split between the areas in such a way that area 1 is exporting 413MW to area 2. The reference load-flow with M2 considered the slack machine is such that all generators are producing about 700 MW each. Opening the Powergui and selecting Machine and Load-Flow Initialization can see the results. The other parameters of the system are given in the appendix.

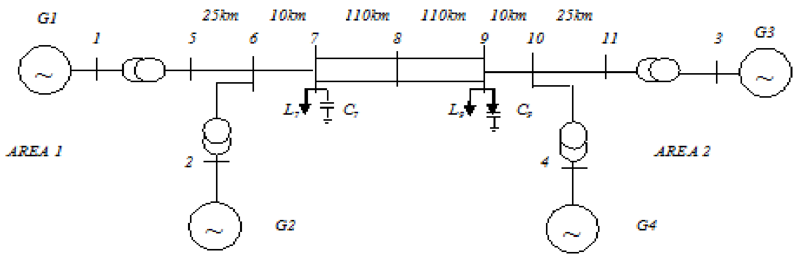


Fig 2. One line diagram of two-area four-machine system

4.1 System model:

The two area four machine test system model shown in Fig 2.is developed using MATLAB-SIMULINK. In this model, both area 1 and area 2 has the similar arrangements. The design parameters of the model are given in the appendix Figures and Tables

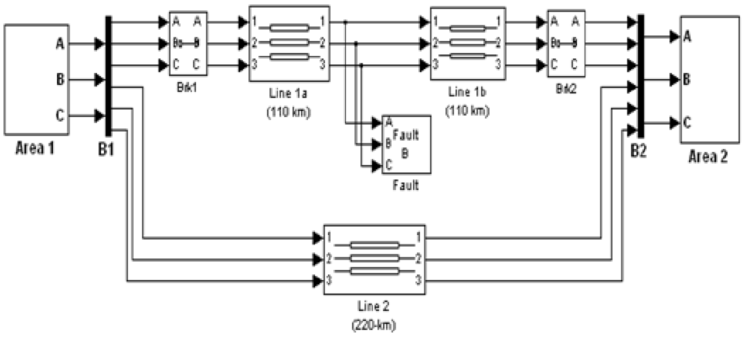


Fig 3. Simulink model of two area four machine system

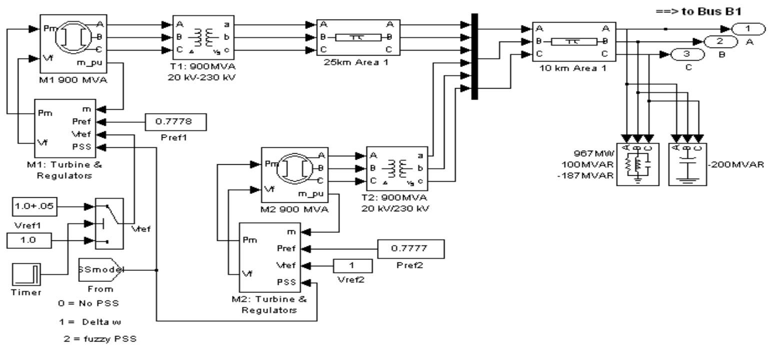


Fig 4. Internal configuration of area 1(subsystem)

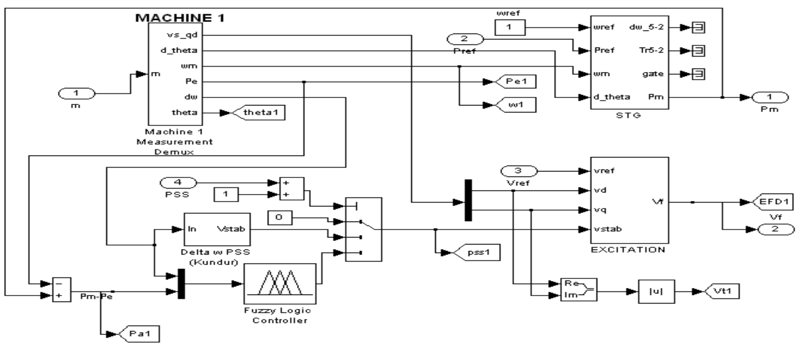


Fig 5. Internal configuration of Turbine and regulator (subsystem)

V. Simulation Study

To investigate the two-area four-machine system performance the following disturbances were considered in the simulation studies

- ❖ Steady state operation
- ❖ L-G fault at any one of the phase
- ❖ Three phase to ground fault

5.1 Steady state operation

Various performance such as terminal voltage (V_t), speed deviation (dω), active power deviation (P_a) and active power transfer from bus 1 to bus2 (P) of the proposed fuzzy logic power system stabilizer (FLPSS) is compared with conventional power system stabilizer (Δ-ω) and system without PSS for steady state operations is shown in Figure 5.1 – 5.3.

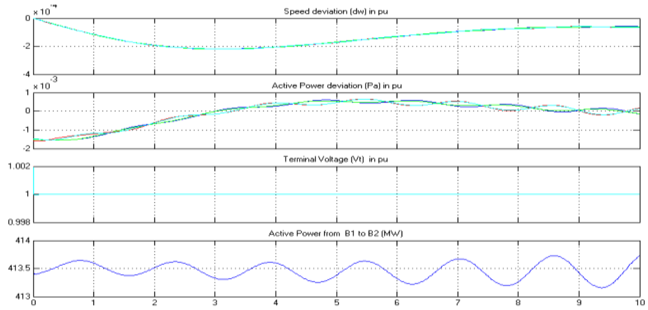


Figure 6. System Response with out PSS

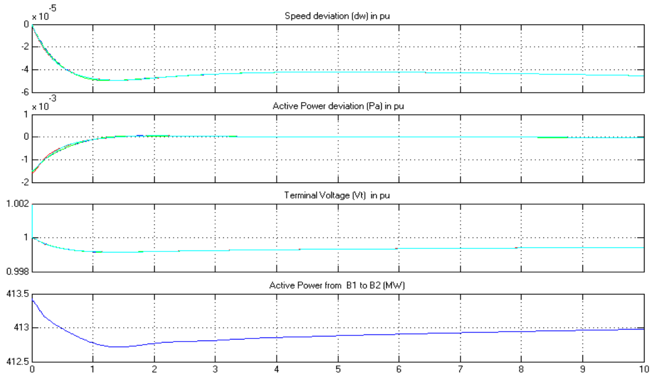


Figure 7. System Response with Delta-ω PSS

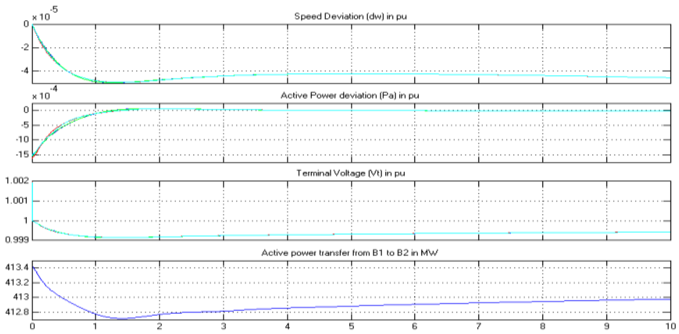


Figure 8. System Response with fuzzy PSS

From the results the system without PSS, the system response is highly oscillatory. The system with PSS is effective for reducing the settling time and a PSS is required to damp the system oscillations. By considering the whole system response the system with fuzzy logic PSS settles down much faster than the system with conventional PSS.

5.2. Single Phase Fault

Figure 5.4.Shows the system performance of with out PSS for single phase to ground fault occurs on the line 1 at 110 km. A single-phase fault were applied at 1.0 sec and cleared at 1.2 sec. Figure 5.5.shows the

various system responses under delta w PSS. figure.shows the various system responses of the fuzzy logic power system stabilizer. It should be noted that the oscillation under system with fuzzy logic PSS decays faster than under system with delta w PSS. Fuzzy logic power system stabilizer achieves a significantly fast damping for power flow from bus 1 to bus 2

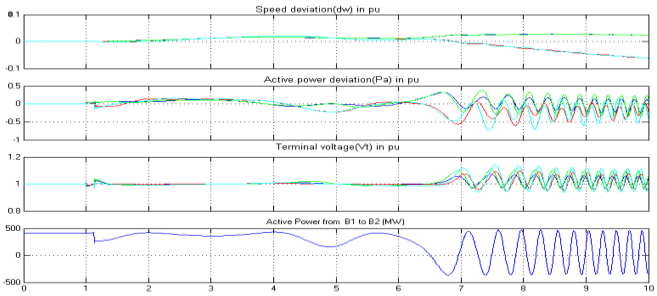


Figure 9. System Response with out PSS

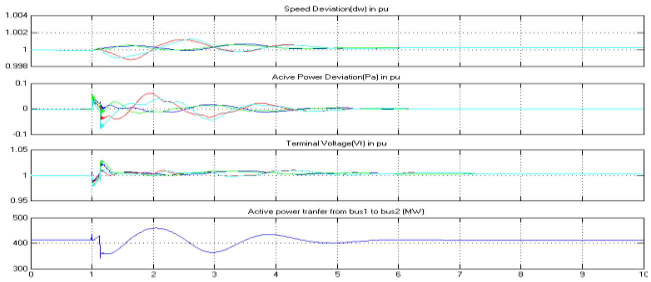


Figure 10. System Response with Delta-ω PSS

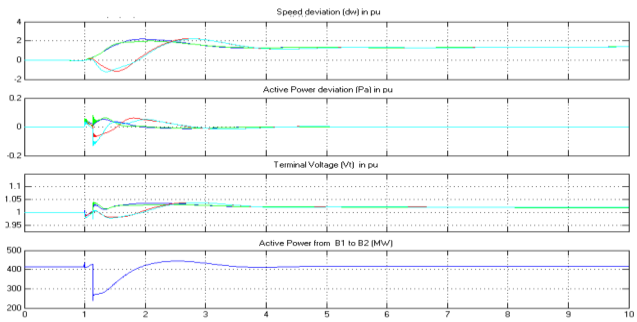


Figure 11. System Response with fuzzy PSS

5.3. Three-Phase to Ground Fault

A three-phase fault of 0.2sec duration is simulated at line 1. Figure 5.7. shows the response of system under with out PSS. Figure 5.8.presents the result of the examined power system under delta-ω PSS. Figure 5.9. shows the response of system with fuzzy logic power system stabilizer. It should be noted that the oscillation under system with fuzzy logic PSS decays faster than under system with delta-ω PSS. The system with delta-ω PSS and without PSS takes longer time to stabilize the power flow from bus1 to bus2 and active power deviation.

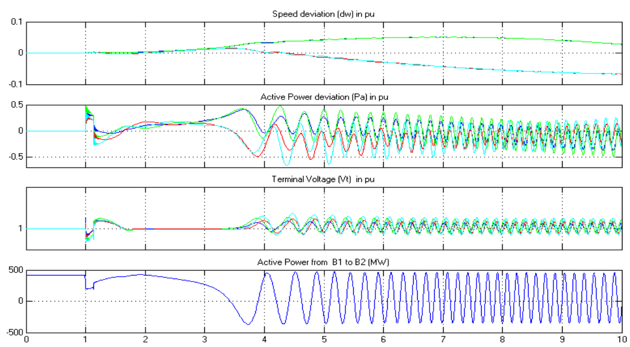


Figure 12.System Response with out PSS

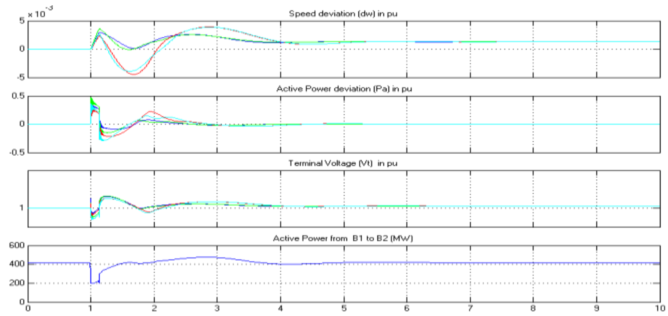


Figure 13.System Response with Delta-ω PSS

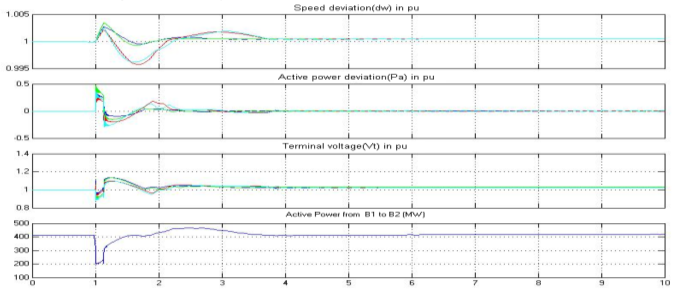


Figure 14.System Response with fuzzy PSS

VI. Conclusion

This paper has been proposed a fuzzy logic based power system stabilizer for two-area four-machine system. The performances of the system during steady state, single-phase and three-phase fault conditions are performed. The resultant characteristics of speed deviation, active power deviation, terminal voltage and active power transfer from bus1 to bus 2 are observed for the three conditions mentioned above. The test also done for delta-omega stabilizer and without power system stabilizer. For the disturbance investigated, the fuzzy logic power system stabilizer (FLPSS) has increased the damping of the system causing it to settle back to steady state in much less time than the conventional power system stabilizer (CPSS). The FLPSS, though rather basic in its control proves that it is indeed a good controller due to its simplicity.

VII. Appendix

7.1 **Generator:**

The generator parameters in per unit on the rated MVA and kV base are as follows:

X_d=1.8
X_q=1.7
X_l=0.2
X'_d=0.3
X'_q=0.55
X''_d=0.25
X''_q=0.25
R_s=0.0025
T'_{d0}=8.0s
T'_{q0}=0.4s
T''_{d0}=0.03s
T''_{q0}=0.05s
A_{sat}=0.015
B_{sat}=9.6
Ψ_{T1}=0.9
H=6.5(for G1 and G2)
H=6.175(for G3 and G4)
K_D=0

7.2 **Transformer:**

Each step-up transformer has an impedance of 0+j0.05 per unit on 900 MVA and 20/230 kV base.

7.3 **Transmission line:**

The parameters of the lines in per unit on 100 MVA, 230 kvbase are

r= 0.0001pu/k
X_l = 0.001pu/km
b_c= 0.00175pu/km

7.4 Loading of generating units:

G1: P=700 MW Q=185 MVAr, E_t=1.03∟20.2°

G2: P=700 MW, Q=235 MVAr, E_t=1.01∟10.5°

G3: P=719 MW, Q=176 MVAr, E_t=1.03∟6.8°

G4: P=700 MW, Q=202 MVAr, E_t=1.01∟-17.0°

7.5 Loads:

The loads and reactive power supplied (Qc) by the shunt capacitors at buses 7 and 9 are as follows
Bus7: P_L=967MW,Q_L=100MVAr,Q_C=200 MVAr
Bus9: P_L=1767MW, Q_L=100MVAr, Q_C=350MVAr

7.6 Delta ω PSS:

K_A=200.0
T_R=0.01
K_{STAB}=20.0
T_W=10.0
T_1=0.05
T_2=0.02
T_3=3.0
T_4=5.4

References

[1]. L.Koundinya,Kalyan,Mukkamula,Yetukuri Lakshman,Kambhampati Tejaswi,Anusha Jadyada"Application of Fuzzy Logic Power System Stabilizers to Transient Stability Improvement In a Large Electric Power System",International Journal Of Applied Research & studies ISSN 2278-9480 iJARS/Vol.II/Issue 1/Jan,2013/297.

[2]. T.Hussein,A.shamekh"Adaptive Rule-base Fuzzy Power System Stabilizer For a Multi-machine System",2013 21st Mediterranean Conference on control & Automation (MED) Platanias-chania,crete,Greece,june25-28,2013

[3]. E. Nechadi and M.N. Harmas **"**Power System Stabilizer Based on Global Fuzzy Sliding Mode Control**"**balkan journal of electrical & computer engineering, 2013, Vol.1, No.2 Copyright © BAJECE ISSN: 2147-284X September 2013 Vol:1 No:2

[4]. T.Hussein,A.shamekh"Performance Assessment of Fuzzy Logic Power System Stabilizer on North Benghazi Power Plant", Conference Papers in Engineering, volume 2013,ArticleID 636808.

[5]. Vijay Kumar Tayal,J.S.Lather"Digital Simulation of Reduced Rule Fuzzy Logic Power System Stabilizer for Analysis of Power System Stability Enhancement"International Journal of Computer Applications(0975-888)volume 47- No.7,june 2012.

[6]. CH.S.K.B.Pradeepkumar, V.S.R.Pavan Kumar.Neeli ",Enhancement Of Power System Stability Using Fuzzy Logic Based Power System Stabilizer" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 July-August2012

[7]. Tejaswita Khobaragade, Amol Barve Departement of Electrical and Electronics Engineering, LNCT Bhopal "Enhancement of Power System Stability Using Fuzzy Logic Controller" International Journal of Power Electronics and Drive System (IJPEDS) Vol.2, No.4, December 2012, pp. 389~401 ISSN: 2088-8694 _ 389

[8]. Tejaswita Khobaragade,Amol Barve" Enhancement of Power System Stability Using Fuzzy Logic Controller",International Journal of Power Electronics and Drive System(IJPEDS)vol.2,No.4,December 2012,pp.389~401 ISSN:2088-8694.

[9]. Dr.A.Taifour Ali,Dr.Eisa Bashier M Tayeb,Ms.Kawthar A.Adam"A Multi Machine Power System Stabilizer Using Fuzzy Logic Controller",International Journal Of Computational Engineering and Research(ijceronline.com)Vol.2 Issue.6,October 2012.

[10]. N.Nallathambi, P.N.Neelakantan,"Fuzzy Logic Based Power System Stabilizer" 0-7803-8655-8/04@IEEE2004.