Damping Of Low Frequency Oscillations In Power System Using Device Upfc With Fuzzy Logic

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Abstract—
Power stability is an important issue that is becoming increasingly important to an power systems at all levels. We are unable to achieve the stability of the system due to some factors. Low frequency oscillation's is one of the major factors that affect the transmission line capacity. Traditionally power system stabilizers(PSS) are being used to damp these inevitable oscillations. In advanced technology FACTS devices such as unified power flow controllers (UPFC) are used to control the power flow in transmission lines. They can also replace the PSS to damp the low frequency oscillations effectively through direct control of voltage and power. In our model, single machine infinite bus power system with UPFC is considered. The designed FUZZY based UPFC controllers adjusts four UPFC inputs by appropriately processing of input error signal and provides an efficient damping. The results of the simulation show that the UPFC with FUZZY LOGIC controller is effectively damping the LOW FREQUENCY OSCILLATIONS.
Keywords—Low frequency Oscillations (LFO), Unified Power flowController(UPFC), Fuzzy logic,Damping controller,Flexiable AC transmission System (FACTS)

I.INTRODUCTION

The demand for electric power is increasing day by day The growing demand of power and environment concern necessitated a review of the traditional power system concepts and practices to achieve greater operating flexibility and better utilization of existing transmission system rapid development of power electronics technology provides exiting to develop new power system equipments for better utilization of exciting system. FACTS devices, which provides the needed correction of transmission functionality in order to fully utilize the existing the transmission systems FACTS technology based on use of reliable high speed
Power electronics, advanced control been demonstrated successfully and continuous to be implemented at transmission locations in various parts of the world the installed FACTS controllers have provided new possibilities and unprecedented flexibility aiming at maximizing the utilization of transmission assets efficiently and reliably.

Now a days the electric power systems is in transition to a fully competitive deregulated scenario. Under this circumstances any power system controls such as frequency and voltage controls will be served as an ancillary services. Especially, in the case that the proliferation of non-utility generations, i.e., independent power producers that do not possess sufficient frequency control capabilities, tends to increase considerable. Furthermore, various kinds of apparatus with large capacity and fast power consumption such as magnetic levitation transportation, a testing plant for nuclear fusion, or even an ordinary scale factory like a steel manufacturer, increase significantly. In future when these loads are concentrated on a power system, they may cause a serious problem of frequency oscillations. The conventional frequency control, i.e., governor may no longer able to absorb these oscillations and this becomes challenging and is highly expected in the future.

The problem of poorly damped low frequency oscillations associated with generator rotor swings has been a matter of concern to power system stabilizer (PSS). In addition, HVDC, SVC controllers have also been used to damp these low frequency oscillations. The advent of high power equipments to improve the utilization of transmission capacity provides system planers with additional leverage to improve stability of the system. Traditionally, power system stabilizers are being used to damp low frequency oscillations effectively through direct control of voltage and power.

It is a new approach to the implementation of the UPFC based on a multiple input single output fuzzy logic controller in a single machine infinite bus power system.

II. DYNAMIC MODELING OF POWER SYSTEM WITH UPFC

Fig. 1 shows a single-machine-infinite-bus (SMIB) system with UPFC. In Fig. 1 me, mb and δe, δb are the amplitude modulation ratio and phase angle of the reference voltage of each voltage source converter respectively.

These values are the input control signals of the UPFC.

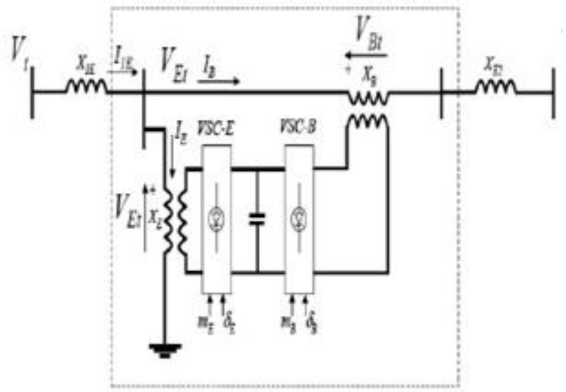


Fig. 1. UPFC installed in a single-machine infinite-bus power system.

A linearized model of the power system is used in studying dynamic studies of power system. In order to consider the effect of UPFC in damping of LFO, the dynamic model of the UPFC is employed. The Dynamic model of the SMIB with UPFC can be represented as

$$\begin{bmatrix} \dot{\Delta\delta} \\ \dot{\Delta\omega} \\ \dot{\Delta E'_q} \\ \dot{\Delta E_{fd}} \\ \dot{\Delta v_{dc}} \end{bmatrix} = \begin{bmatrix} 0 & \omega_0 & 0 & 0 \\ -\frac{K1}{M} & -\frac{D}{M} & -\frac{K2}{M} & 0 \\ -\frac{K4}{T'do} & 0 & -\frac{K3}{T'do} & \frac{1}{T'do} \\ -\frac{KAK5}{TA} & 0 & -\frac{KAK6}{TA} & -\frac{1}{TA} \\ K7 & 0 & K8 & 0 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta\omega \\ \Delta E'_q \\ \Delta E_{qe} \end{bmatrix}$$

$$+ \begin{bmatrix} 0 \\ -\frac{Kpd}{M} \\ -\frac{Kqd}{T'do} \\ -\frac{KAKvd}{TA} \\ -K9 \end{bmatrix} \Delta v_{dc} + \begin{bmatrix} 0 & 0 & 0 & 0 \\ -\frac{Kqe}{M} & -\frac{Kp\delta e}{M} & -\frac{Kpb}{M} & -\frac{Kpb}{M} \\ -\frac{Kpe}{T'do} & -\frac{Kq\delta e}{T'do} & -\frac{Kqb}{T'do} & -\frac{Kqb}{T'do} \\ -\frac{KAKve}{TA} & -\frac{KAKv\delta e}{TA} & -\frac{KAKvb}{TA} & -\frac{KAKv\delta b}{TA} \\ K_{ce} & K_{c\delta e} & K_{cb} & K_{c\delta e} \end{bmatrix} \begin{bmatrix} \Delta mE \\ \Delta\delta E \\ \Delta mB \\ \Delta\delta B \end{bmatrix}$$

where mE mB, E and B are the deviations of input control signals of upfc

III. DESIGN OF FUZZY LOGIC CONTROLLER

There are two major types of fuzzy controllers, namely Mamdani type and Takagi-Sugeno (TS) type. The classification depends on the type of fuzzy rules used. If a fuzzy controller uses the TS type of fuzzy rules, it is called a TS fuzzy controller. Otherwise, the controller is named a Mamdani fuzzy controller. Throughout this paper, attention is focused on the Mamdani type fuzzy controller in order to damp the low frequency oscillationsof the power system.

Angular velocity deviation Δω and load angle deviation Δδ is used as the fuzzy controllers inputs. One of the upfc inputs has been controlled via fuzzy controller output as shown in Fig. 2.

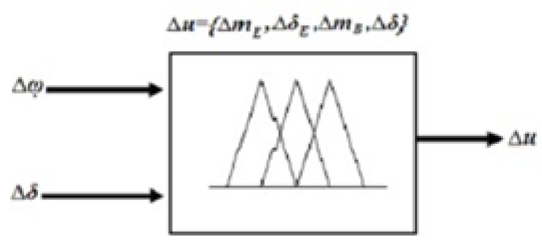


Fig. 2. Fuzzy Logic Controller

Seven membership functions are used in this work are triangular and trapezoidal in shape. The inputs and ouputs are fuzzified using seven fuzzy sets: LN (large negative), MN (medium negative), SN (small negative), Z (zero), SP (small positive), MP (medium positve), andLP(large positive).The membership functions of the inputand output signals are shown in Fig. 3, Fig. 4 and Fig. 5.

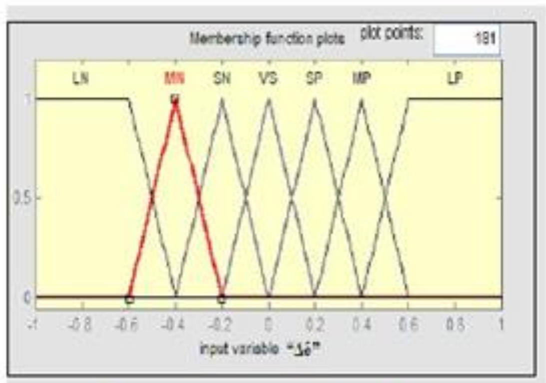


Fig. 3. Membership functions for input Δδ

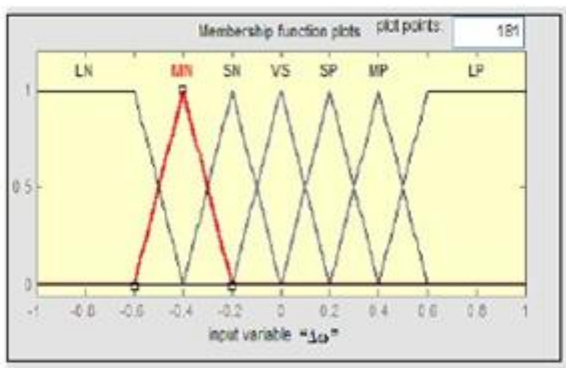


Fig. 4. Membership functions for input Δω

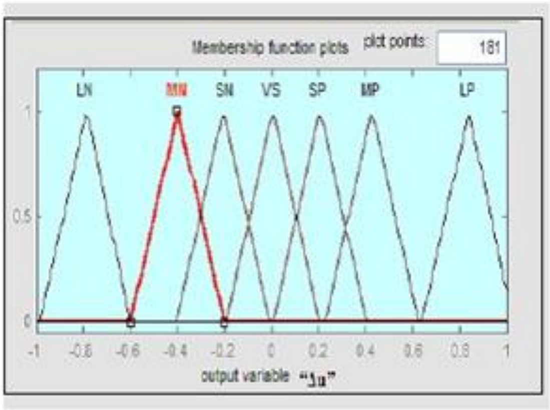


Fig. 5. Membership functions for output Δu

The rules used in this controller are chosen as follows:

1. If $\Delta\delta$ is LP and $\Delta\omega$ is LP then Δu is LP.
2. If $\Delta\delta$ is LP and $\Delta\omega$ is MP then Δu is LP.
3. If $\Delta\delta$ is LP and $\Delta\omega$ is SP then Δu is LP.
4. If $\Delta\delta$ is LP and $\Delta\omega$ is VS then Δu is MP.
5. If $\Delta\delta$ is LP and $\Delta\omega$ is SN then Δu is MP.
6. If $\Delta\delta$ is LP and $\Delta\omega$ is MN then Δu is SP.
7. If $\Delta\delta$ is LP and $\Delta\omega$ is LN then Δu is VS.
8. If $\Delta\delta$ is MP and $\Delta\omega$ is LP then Δu is LP.
9. If $\Delta\delta$ is MP and $\Delta\omega$ is MP then Δu is LP.
10. If $\Delta\delta$ is MP and $\Delta\omega$ is SP then Δu is MP.
11. If $\Delta\delta$ is MP and $\Delta\omega$ is VS then Δu is MP.
12. If $\Delta\delta$ is MP and $\Delta\omega$ is SN then Δu is SP.
13. If $\Delta\delta$ is MP and $\Delta\omega$ is MN then Δu is VS.
14. If $\Delta\delta$ is MP and $\Delta\omega$ is LN then Δu is SN.
15. If $\Delta\delta$ is SP and $\Delta\omega$ is LP then Δu is LP.
16. If $\Delta\delta$ is SP and $\Delta\omega$ is MP then Δu is MP.
17. If $\Delta\delta$ is SP and $\Delta\omega$ is SP then Δu is MP.
18. If $\Delta\delta$ is SP and $\Delta\omega$ is VS then Δu is SP.
19. If $\Delta\delta$ is SP and $\Delta\omega$ is SN then Δu is VS.
20. If $\Delta\delta$ is SP and $\Delta\omega$ is MN then Δu is SN.
21. If $\Delta\delta$ is SP and $\Delta\omega$ is LN then Δu is MN.
22. If $\Delta\delta$ is VS and $\Delta\omega$ is LP then Δu is LP.
23. If $\Delta\delta$ is VS and $\Delta\omega$ is MP then Δu is LP.
24. If $\Delta\delta$ is VS and $\Delta\omega$ is SP then Δu is LP.
25. If $\Delta\delta$ is VS and $\Delta\omega$ is VS then Δu is LP.
26. If $\Delta\delta$ is VS and $\Delta\omega$ is SN then Δu is LP.
27. If $\Delta\delta$ is VS and $\Delta\omega$ is M then Δu is LP.
28. If $\Delta\delta$ is VS and $\Delta\omega$ is L then Δu is LP.
29. If $\Delta\delta$ is SN and $\Delta\omega$ is LP then Δu is LP.
30. If $\Delta\delta$ is SN and $\Delta\omega$ is MPthen Δu is LP.
31. If $\Delta\delta$ is SN and $\Delta\omega$ is SPthen Δu is LP.
32. If $\Delta\delta$ is SN and $\Delta\omega$ is VSthen Δu is LP.
33. If $\Delta\delta$ is SN and $\Delta\omega$ is SN then Δu is LP.
34. If $\Delta\delta$ is SN and $\Delta\omega$ is MNthen Δu is LP.
35. If $\Delta\delta$ is SN and $\Delta\omega$ is LNthen Δu is LP.
36. If $\Delta\delta$ is MNand $\Delta\omega$ is LP then Δu is LP.
37. If $\Delta\delta$ is MNand $\Delta\omega$ is MP then Δu is LP.
38. If $\Delta\delta$ is MN and $\Delta\omega$ is SP then Δu is LP.
39. If $\Delta\delta$ is MN and $\Delta\omega$ is VS then Δu is LP.
40. If $\Delta\delta$ is MN and $\Delta\omega$ is SN then Δu is LP.
41. If $\Delta\delta$ is MN and $\Delta\omega$ is MN then Δu is LP.
42. If $\Delta\delta$ is MN and $\Delta\omega$ is LN then Δu is LP.
43. If $\Delta\delta$ is LN and $\Delta\omega$ is LP then Δu is LP.
44. If $\Delta\delta$ is LN and $\Delta\omega$ is MP then Δu is LP.
45. If $\Delta\delta$ is LN and $\Delta\omega$ is SP then Δu is LP.
46. If $\Delta\delta$ is LN and $\Delta\omega$ is VS then Δu is LP.
47. If $\Delta\delta$ is LN and $\Delta\omega$ is SN then Δu is LP.
48. If $\Delta\delta$ is LN and $\Delta\omega$ is MN then Δu is LP.
49. If $\Delta\delta$ is LN and $\Delta\omega$ is LN then Δu is LP.

The membership functions of the inputs, output and rule base for all the controllers can be the same. The only difference is the range of these values.

IV. SIMULATION RESULTS

Firstly Simulation is done with the help of MATLAB software for the model of SMIB with UPFC as shown in the section 2. taking step change in mechanical input power (Pm = 0.01 pu.). In This simulation UPFC has no controller. The results obtained shows that the system is having oscillations and the system is poorly damped as shown in Fig. 6.

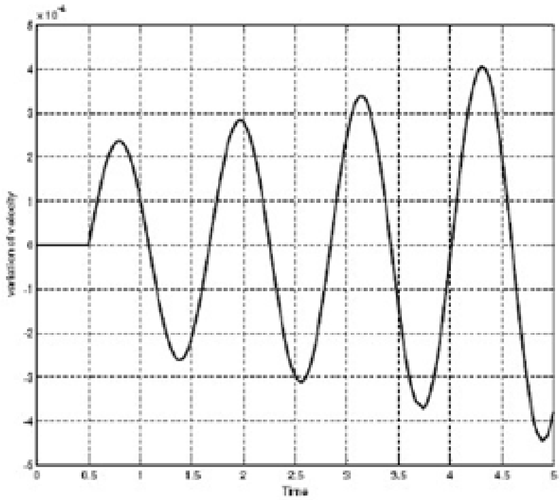
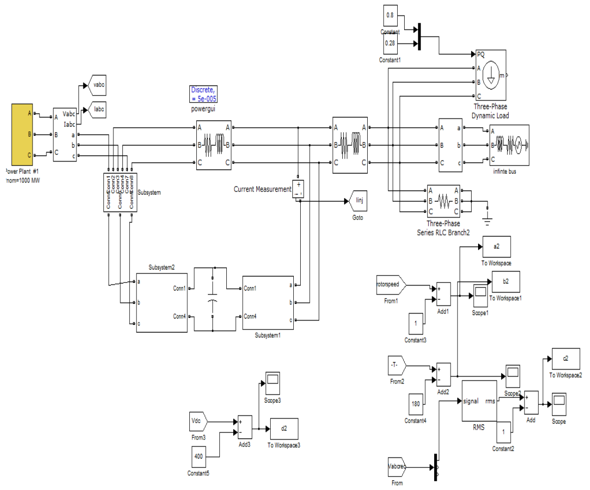


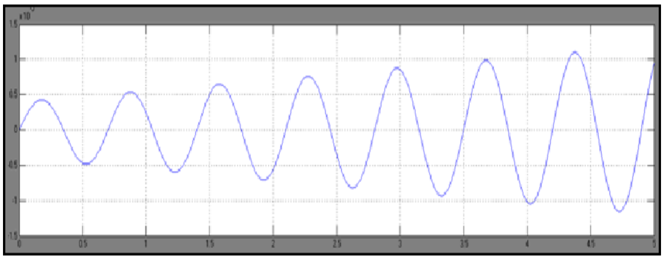
Fig. 6 Response of system without any damping controller

Next, the simulation is performed with the same step change in mechanical input power but the UPFC is controlled by different fuzzy controllers namely m E controller, mB controller, δE controller and δB controller. The performance of the system with mE controller, mB controller, δE controller and δB controller is shown in Figs. 7, 8, 9 and 10 respectively.

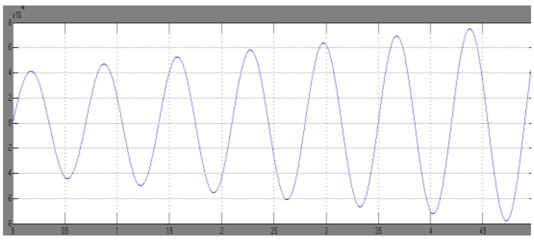


SIMULATION OF SMIB USING UPFC WITH FUZZY

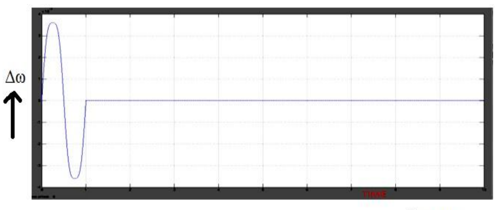
Rotor speed vs time without any controller



Rotor speed vs time with upfc



Rotor speed vs time with upfc and fuzzy logic



V. CONCLUSION

The above simulations shows that the system considered when used without any damping controller is undamped in nature.The fuzzy controller is designed for this UPFC controller. The simulation results shows that when there is a small perturbance in the power system, the proposed UPFC based fuzzy controller is effectively damping the oscillations.

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