LOAD FREQUENCY CONTROL OF INTERCONNECTED SYSTEM WITH FUZZY LOGIC CONTROLLER

[1]Mrs. M. Nagajyothi, [2]Mr.T.Mukesh
[1]Assistant Professor, [2]PG Student
Email:[1]Nagajyothi_m@vnrvjiet.in, [2]mukesh0254@gmail.com

Abstract: This paper deals with load frequency control or automatic generation control of an interconnected system. The system is incorporated with conventional proportional -integral (PI) and fuzzy logic controller (FLC). Time domain simulation is used to study the performance, when a step load disturbance is given in either area of the system. Finally the simulation results of conventional PI controller is compared with fuzzy logic controller and proved that FLC yields better control performance, Simulations have been performed using Matlab.

Key words: Inter connected power system, PI controller, and Fuzzy logic controller

I. INTRODUCTION

The successful operation of interconnected electric power system needs the matching of total generation with total load demand plus system losses. The operating point of an electric power system may change with respect to time which may yield undesirable effects. This is normally overcome by controllers or automatic generation controllers, by properly adjusting the area control error (ACE) which comprising system frequency and tie line power exchanges. This control philosophy is widely used and generally referred as tie line bias control.

In multi area system a change of power in one area is met by the increase in generation in all areas associated with a change in the tie-line power and a reduction in frequency. In the normal operating state the power system demands of areas are satisfied at the nominal frequency. A simple Control strategy for the normal mode is to operates in such a way that

1. Keep frequency approximately at nominal value.
2. Each area should absorb its own load changes.
3. Maintain the tie-line flow at about schedule.

Controller must be sensitive against changes in frequency and load. To analyze the control system mathematical model must be established. There are two models which are widely used,

1. Transfer function model
2. State variable approach.

The most applied controller is Conventional Proportional Integral (PI). It is easier but usually gives large settling time. Most research going on now is based on artificial intelligent systems (fuzzy and neural networks). The inherent gain of these techniques is that they do not require the system model and identification but depend on human expertise knowledge of the behavior.

II TWO AREA SYSTEM

A two area system consists of two single area systems, connected through a power line called tie-line, is shown in the Figure 1. Each area feeds its user pool, and the tie line allows electric power to flow between the areas. Information about the local area is found in the tie line power fluctuations. Therefore, the tie- line power is sensed, and the resulting tie-line power is fed back into both areas. It is conveniently assumed that each control area can be represented by and equivalent turbine, generator and speed governor system.

Fig. 1 shows the block diagram representing the two area power system. This model includes the conventional integral controller gains (k1,k2) and the two auxiliary (stabilizing) signals ($\Delta u1$,$\Delta u2$). The stabilizing signals will be generated by the proposed fuzzy logic load frequency controller (FLFC).

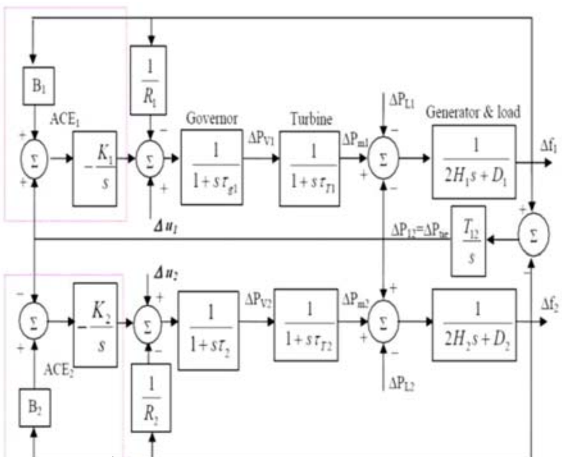

Fig 1 Two-area power system

In applying the PI controller to our Two-Area system the control error for each area consists of a linear combination of frequency and Tie-line error.

$$ACE1 = \Delta P12 + B1\Delta f1$$

$$ACE2=\Delta P21+B2\Delta f2$$

The speed changer commands will thus be of the Form

$$\Delta u1 = -k1\int \Delta P12 \; + \; B1\Delta f1 \, dt$$

$$\Delta u2 = -k2\int \Delta P21 \; + \; B2\Delta f2 \, dt$$

The constants $k1$, $k2$ are the integrator gains and the constants B1, B2 are the frequency bias parameters. The minus sign must be included since in each area should increase its generation if either its frequency or its tie-line power increment is negative.

III INTEGRAL CONTROL

The integral control composed of a frequency sensor and an integrator. The frequency sensor measures the frequency error Δf and this error signal is fed into the integrator

The input to the integrator is called the Area Control Error (ACE). The ACE is the change in area frequency, which when used in an integral control loop, forces the steady-state frequency error to zero.

The integrator produces a real-power command signal ΔPC and is given by

$$\Delta PC = -KI \int \Delta f \, dt$$

ΔPC = input of speed –changer

KI = Integral gain constant

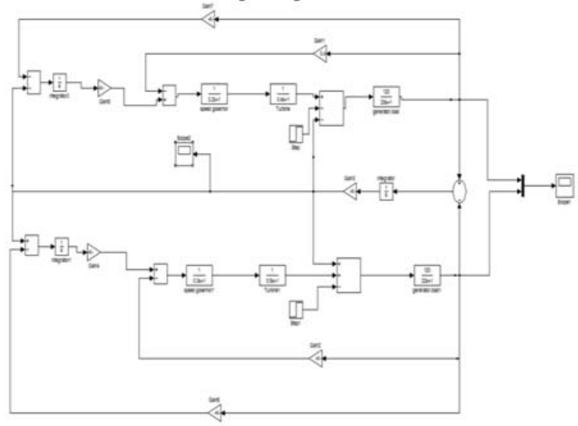

Fig 2 Two-area with PI

IV FUZZY LOGIC CONTROLLER

There are three principal elements to a fuzzy logic controller:

1. Fuzzification module (Fuzzifer)
2. Rule base and Inference engine
3. Defuzzification module (Defuzzifier)

Fuzzy control is based on a logical system called fuzzy logic. It is much close in spirit to human Thinking than classical logical systems. The LFC has been reported in several papers is to maintain Balance between production and consumption of electrical power. Due to the complexity and Multi-variable nature of power systems, a conventional control method has not provided satisfactory solutions.

The fuzzy logic control has tried to handle the robustness, reliability and nonlinearities associated with power system controls. Therefore a fuzzy logic controller (FLC) becomes nonlinear and adaptive in nature having a robust performance under parameter variations with the ability to get desired control actions for complex uncertain, and nonlinear systems without their mathematical models and parameter estimation.

This work proposes a fuzzy controller with up to 25 rules with 7 membership function as negative big (NB), negative medium (NM), negative small (NS), zero (ZE), positive small (PS), positive medium (PM), positive big (PB) . For the control of Area control error (ACE), there are two controllers, ACE and d/dt(ACE) [4]

Triangular membership functions are used for both the inputs and output. The Defuzzification method employed is the centroid method [4].
The overall two area system with Fuzzy logic is shown in Fig 3

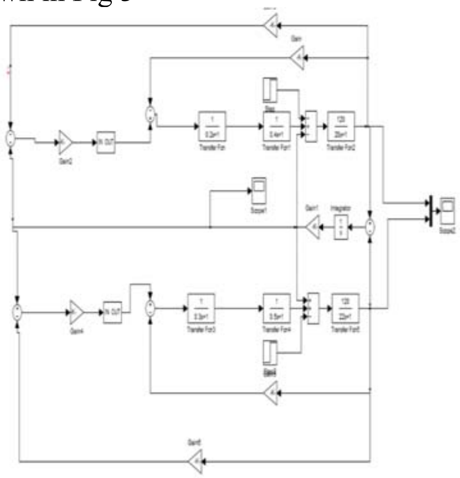

Fig 3 two area fuzzy simulation model

V.SIMULATION AND RESULTS

The following simulations were performed in order to investigate the performance of the proposed fuzzy logic controller over the conventional integral controller with 0.2 pu change in load of each area in both two area and three area with parameters as indicated in Appendix A.

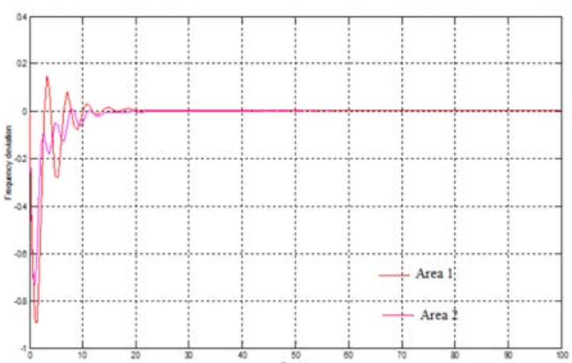

Fig 4 Two area Frequency deviation with PI

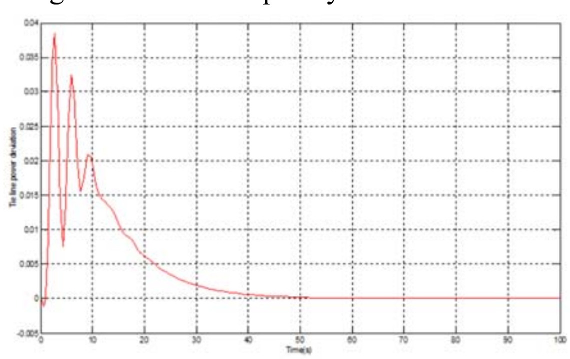

Fig 5 Two area Tie line power deviation with PI

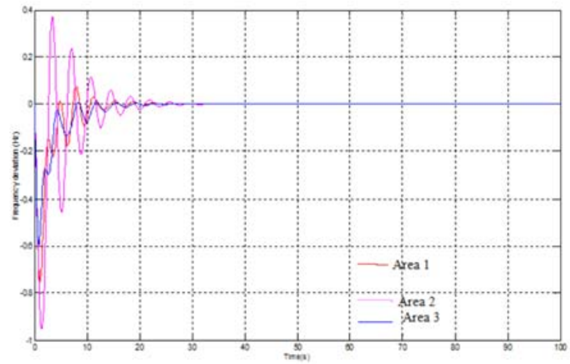

Fig 6 Three area Frequency deviation with PI

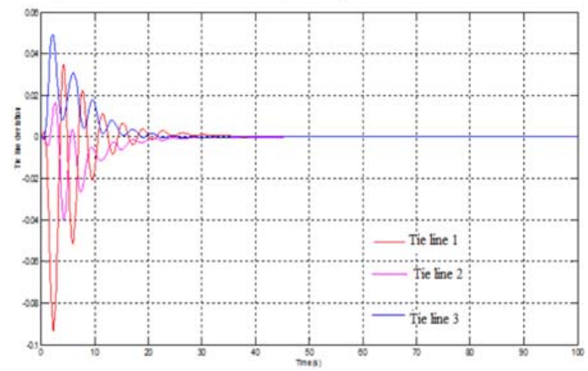

Fig 7 Three area Tie line power deviation with PI

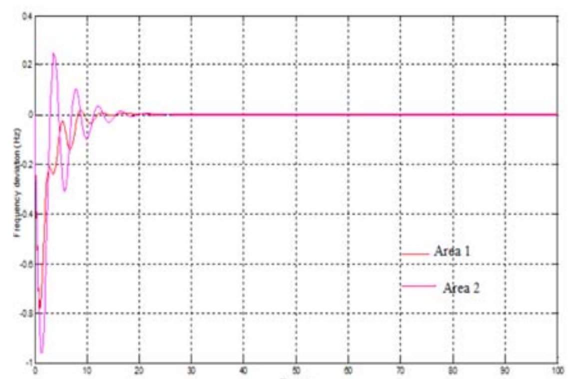

Fig 8 Two area Frequency deviation with Fuzzy

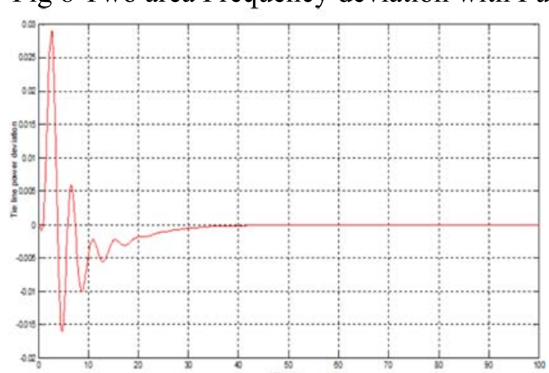

Fig 9 Two area Tie line power deviation with Fuzzy

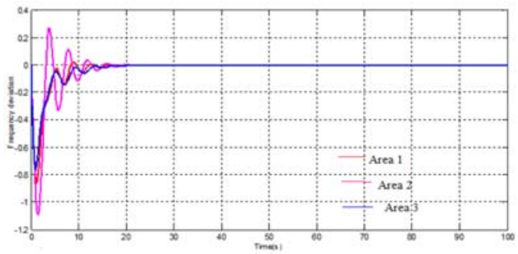

Fig 10 Three are frequency deviation with Fuzzy

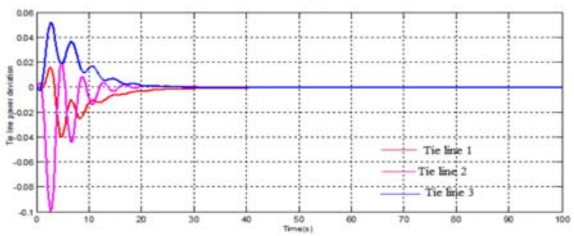

Fig 11 Three area Tie line power deviation with Fuzzy

Appendix A

PARAMETERS	Area 1	Area 2	Area 3
Power system gain constant k_{Ps}	120 Hz p.u/Mw	120 Hz p.u/Mw	120 Hz p.u/Mw
Power system time constant, T_{Ps}	10sec	11 sec	9 sec
Normal frequency f	50 Hz	50 Hz	50Hz
Governor time constant T_{Sg}	0.2 sec	0.3 sec	0.08 sec
Turbine time constant T_t	0.4 sec	0.5 sec	0.28 sec
Speed regulation $1/R$	0.30 Hz/ per unit	0.20 Hz/ per unit	0.25 Hz/ per unit

Conclusion:

This paper presented a fuzzy logic controller to automatic generation control scheme for the interconnected system. The controller performance is observed on the basis of dynamic parameters (i.e.) settling time The conventional PI controller does not provide adequate control performance with 0.2 pu step load disturbance on either area of the system. Fuzzy logic controller has been implemented to improve the dynamic performance of the system (i.e.) to reduce the oscillation and time taken to settle the system. The action of this proposed controller provides satisfactory balance between overshoots and transient frequency oscillations with zero steady state error. This justifies that this model provides a stable representation for an interconnected system.

References

[1] O. I. Elgerd and C. Fosha, „Optimum megawatt frequency control of multi-area electric energy systems,‟ IEEE Trans. Power App. Syst., vol. PAS-89, no. 4, pp. 556–563, Apr. 1970.

[2] Elgerd, O.I, "Electric Energy system theory: An Introduction" McGraw-Hill, TMH edition, 1971

[3] K. C. Divya, and P.S. Nagendra Rao, „A simulation model for "AGC studies of hydrohydro systems" Int. J. Electrical Power & Energy Systems, Vol 27, Jun.- Jul. 2005, pp. 335-342.

[4] D P Kothari I J Nagarath "Modern power System Analysis" McGraw-Hill, TMH edition 1980

[5] Haadi Sadat, "Power Systems Analysis" McGraw-Hill companies Inc. 1999

[6] C. Concordia and L.K. Kirchmayer, „Tie line power and frequency control of electric power systems,‟ Amer. Inst. Elect. Eng. Trans., Pt. II, Vol. 72, pp. 562 572, Jun. 1953. .

[7] S.Sivanagaraju, Gsreenivasan, Power System Operation and Control

[8] A. Nagoorkani Control systems second edition june, 2009 by RBA Publications.

[9] Gopal, M, "Modern control system theory" Wiley Eastern Ltd, 2nd edition 1993.

[10] S. Rajasekaran, G.A. Vijayalakshmi pai, Neural Networks, Fuzzy Logic, and Genetic Algorithms synthesis and Applications 2003 by PHI Learning Private Limited

[11] L.A.Zadeh "Fuzzy sets", *Information and control*, Vol.8, pp.338-353, 1965.

[12] Nathan cohan "some aspects of tie-line bias control on interconnected power systems," AIEE Trans, vol 75, pp 1415-1436, February 1957