A Single Area Load Frequency Control (LFC): Comparative Study Based on Integral and Fuzzy Logic Controller

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***Abstract*: The comparative analysis of integral and fuzzy logic controller for load frequency control has been described in this paper. Local feedback signal from the output to the input has been injected to the controller. A single area power system is simulated to validate the effectiveness of the controller. The effect of system nonlinearity such as Generation Rate Constraint (GRC) and Governor Dead Band has been studied. Simulation has been carried out using MATLAB/ Simulink 2009.**

***Keyword*: Load frequency control, fuzzy logic, dead band.**

I. INTRODUCTION

For the constancy of system frequency to a fine tolerance level to match the system generation with system load is important task. A system load change causes the change in the speed of Turbine-Generator rotor system.

For stabilizing the system frequency Primary control action of the governor control has been initiated. To regulate system frequency to the set nominal value is the primary objective of automatic generation control (AGC). So, Supplementary control action is required to restore frequency to nominal value and also it regulates the net interchange of interconnected power system for the reliability and quality of power supply [1]. Power system nonlinearities (Generation rate constraints (GRC) and governor dead bands) in a single area power system is shown in Fig.1 The operating point of a power system often changes on daily cycle basis . Also, a fixed controller may no longer be suitable [3]. The loading in a power system is never constant. Using fuzzy logic controller stability of a large electric power system can be enhanced [1]. Due to the influence of the control system the dynamic performance of power systems are usually affected by the [4]. To obtain an accurate linear time-invariant models at various point and it is quite difficult [1].Normally, Control feed back as an area control error (ACE) is use as a feedback control through integral controller Optimal control using full state feedback is described in [5]. In [7, 8] using Full state feedback, optimal control has been described. In this paper LFC using fuzzy logic control is presented. Due to no parameter estimation requirement controller can respond very quickly following changes in a system dynamics. It offers flexibility in decisions. It gives interesting interface between man/machine by simplifying rules. Also fuzzy logic gives an efficient way of copying imprecision's in the available knowledge. [1]

Section II contains representation of single area power system including Generation Rate Constraint (GRC) and dead band as non linearities [1, 3]. Section III contains control strategies Integral and proposed fuzzy logic controller. Simulation results and discussion are presented in section IV. The concluding remark are contained in section V.

II. CONVENTIONAL POWER SYSTEM FOR LOAD FREQUENCY CONTROL

When the system load is increased suddenly then the electrical power exceeds the input mechanical power. This inadequacy of power at the load side is met by the kinetic energy of the turbine. Due to this reason the energy that is stored in the machine is reduced and it slow down. The governor then sends signal for supplying more volumes of water, steam or gas to increase the speed of the prime mover to compensate reduction in speed.

In a single area and multi area system feedback control is normally employed through integral controller using area control error (ACE) [6]. To implement such controllers, complete feedback is required [1]. Problems will be generate with such controllers are criticism from power system operators has generated, may degrade robustness and performance of power system due to remote state estimation by observer and difficult to obtain linear time- invariant models at various points [1]. The block diagram of the plant model with generation rate constraint given by $\Delta P_g \leq 0.0015$ p.u. MW/s is shown in figure 2. Effect of governor dead zones non-linearity is described by the function [1]

$$D(v) = \begin{cases} m(v-d), if\ v \geq d \\ 0, if\ -d \leq v \leq d \\ m(v+d), if\ v \leq -d \end{cases}$$

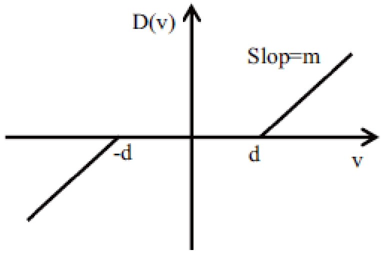

Figure 1 Characteristic of governor dead zones

A new LFC using fuzzy logic control is proposed because of no parameter estimation is required in response to changes in the system dynamics and quick response.

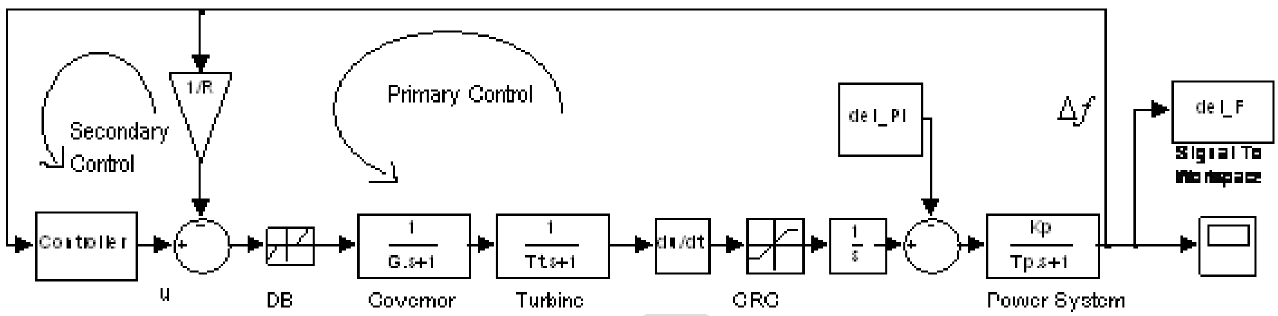

Figure 2 Block diagram of load frequency control for single area power system

III. CONTROL STRATEGY

Two different control strategies are applied to single area load frequency control. Conventional Integral control and fuzzy logic control are as follows.

A. Integral Controller

Controller with gain K_E has been inserted in a controller loop, an input for the controller is Δf and output of the controller is u .

B. Fuzzy Logic Controller

Fuzzy logic has an advantage over other control methods due .o the fact that it does not sensitive to plant parameter variations. The fuzzy logic control approach consists of three stages, namely fuzzification, fuzzy control rules engine, and defuzzification, [6]. To design the conventional fuzzy logic load frequency control, the input signal is the frequency deviation at sampling time and its change is shown in figure 3 and figure 4. While, its output signal is the change of control signal which is shown in figure 5.

Table 1 Fuzzy logic control rules

Framing of the rules						
Input		Δf				
d(Δf)/dt		NB	NM	ZE	PM	PB
	NB	S	M	B	B	VB
	NM	M	B	B	VB	VB
	ZE	B	B	VB	VB	VVB
	PM	B	VB	VB	VVB	VVB
	PB	VB	VB	VVB	VVB	VVB

Triangular membership function shapes for two inputs frequency deviation Δf and change in frequency deviation Δf error and derivative error are chosen to be identical for fuzzy logic control as shown in figure. For optimized control horizontal axis range is taken different values. Table 1 shows framing of rules. The input signals are first expressed in some linguistic variables using fuzzy set notations such as negative big (NB), negative medium (NM), zero (ZE), positive medium (PM) and positive big (PB). The output signals are expressed in linguistic variables using small (S), medium (M), big (B), very big (B).The rules interpreted as follows.

If frequency deviation (Δf) is negative big (NB) and change in frequency deviation d (Δf)/dt is negative big (NB) then output (u) is small (S).

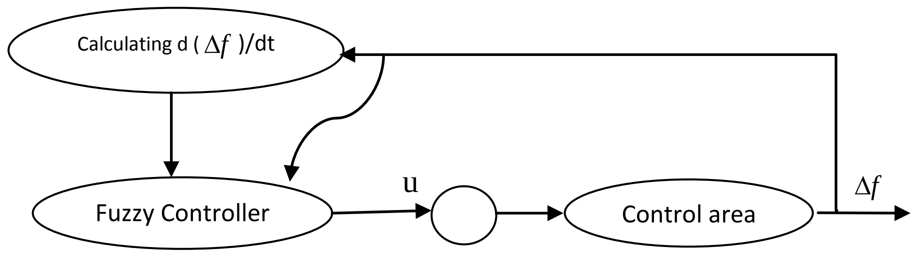

Figure 3 Fuzzy logic power system stabilizer

The membership function sets of Fuzzy logic control (FLC) for single area is shown in figure 4. Triangular shapes membership function of error and derivative error are chosen. However, this horizontal axis range is taken different values because of optimizing controller.

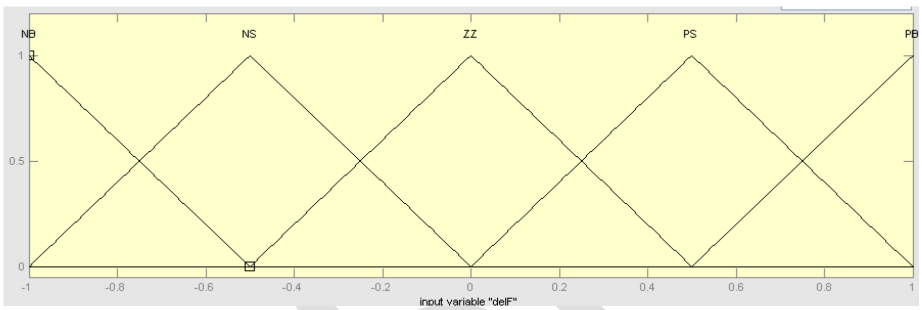

Figure 3 Input 1 membership function: frequency deviation

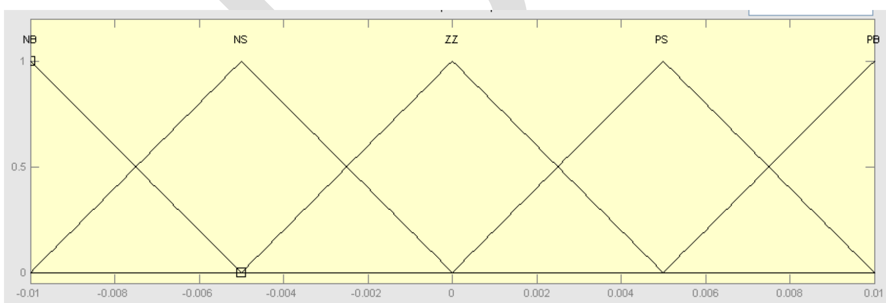

Figure 4 Input 2 membership function: Change in frequency deviation

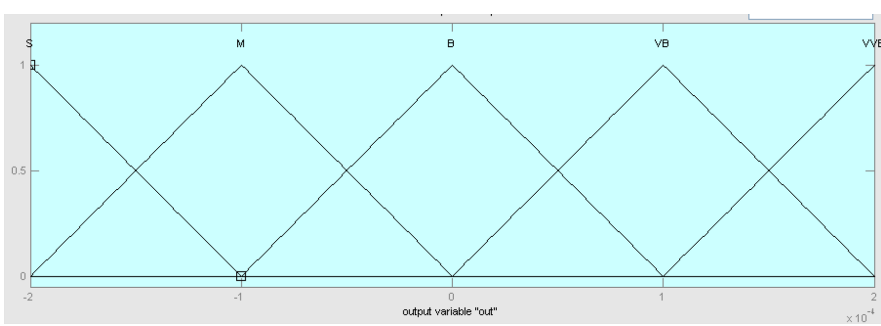

Figure 5 Output membership function :u

IV. SIMULATION RESULTS

A load change of 0.01 p.u as shown in figure 6 and 0.02 p.u as shown in figure 7 was applied for the analysis with the effect of governor dead band (DB) and generation rate constraint (GRC). It is observed from Figure that the fuzzy logic controller reducing the perturbations in frequency and .performance is improving as compared to integral controller. i.e amplitude of deviation and settling time are reducing.

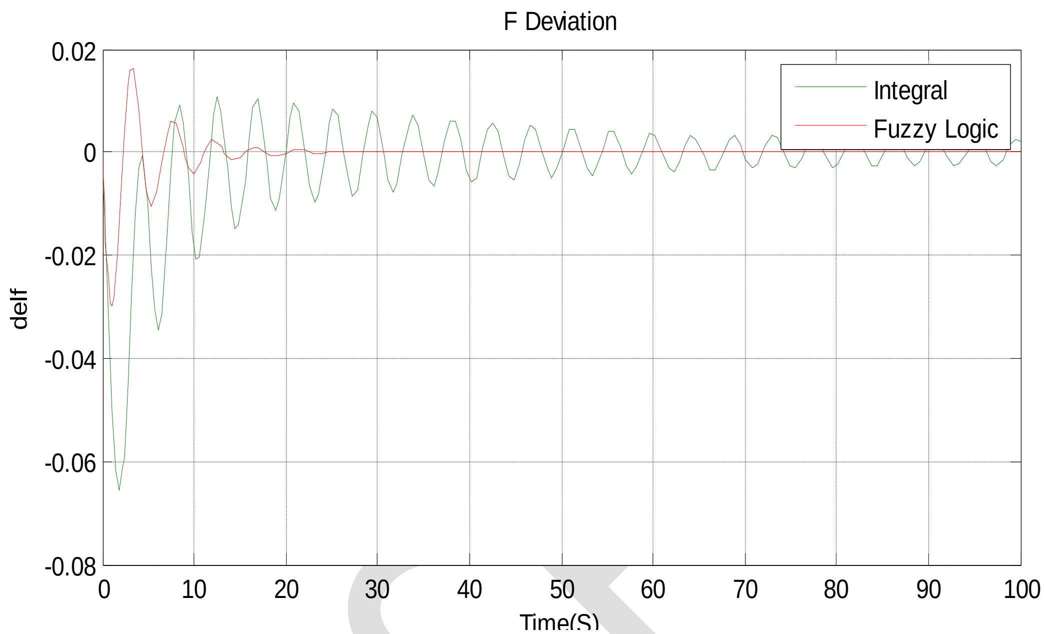

Figure 6 Frequency deviation response due to 0.01 p.u load disturbance with integral and fuzzy logic controller

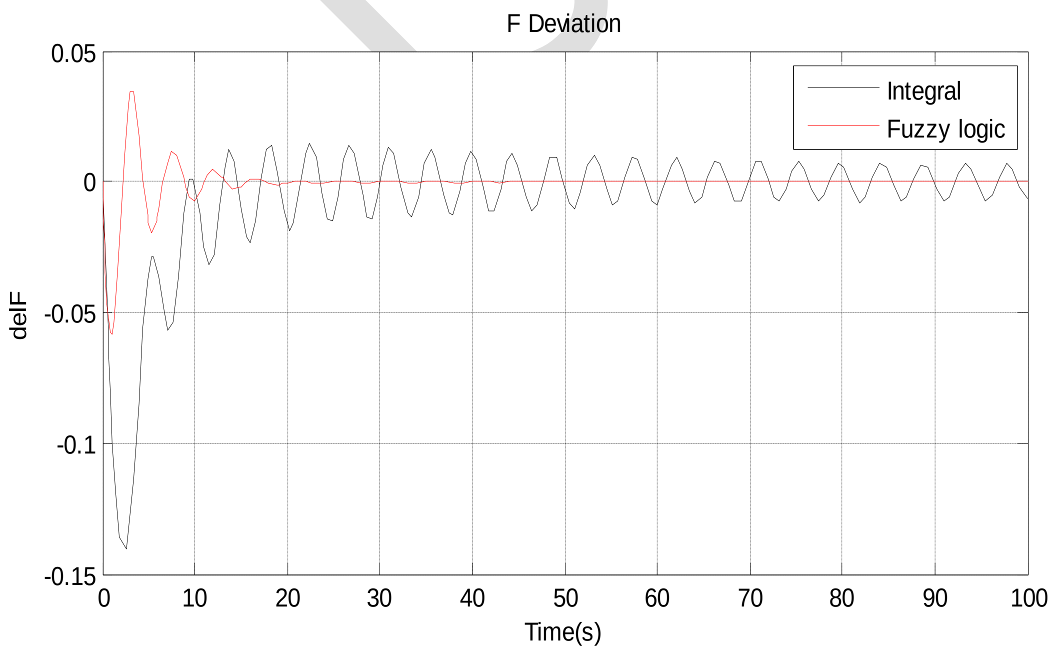

Figure 7 Frequency deviation response due to 0.02 p.u load disturbance with integral and fuzzy logic controller

V. CONCLUSION

In this paper conventional PI controller and Fuzzy Logic controllers for load frequency control for single area power system. The dead band and generation rate constraint as a non linearity has been considered. Triangular shapes membership functions have been considered in fuzzy logic to reduces frequency deviations. To improve the control performance twenty five rules was taken for the inference mechanism. There is a less overshoot and small settling time in case of fuzzy logic controller as compared to conventional PI controller. Fuzzy logic can control non linear systems that would be difficult or impossible to model mathematically.

APPENDIX

Turbine time constant, Tt=0.5, Governor time constant, Tg=0.4, Regulation, R=1/2.4, frequency, f=50 Hz, 2H=20.

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