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Load Frequency Control of Interconnected Hydro-Thermal Power System using Fuzzy and PI Controller

Ammisetty Jayasree
M.Tech Student,
QIS College of Engineering and Technology, Ongole, India.

Sri.R.Sathish Kumar
Associate Professor,
QIS College of Engineering and Technology, Ongole, India.

Dr.B.VenkataPrasanth
Professor & Head,
QIS College of Engineering and Technology, Ongole, India.

ABSTRACT:
Now days in industry or any area increasing load is a vast problem for power generation plants due to increase in demand for power. So making balance between generation and demand is the operating principle of load frequency control (LFC). So there is a need of robust control of both systems frequency and tie-line power flows. This paper deals with Load Frequency Control of two area thermal-hydro system with conventional PI Controller and Fuzzy Logic Controller. This paper shows how to regulate the power supply from interconnected hydro thermal power system by load frequency control (LFC).

Thus the LFC helps in maintaining the scheduled system frequency and tie-line power interchange with the other areas within the prescribed limits. The load frequency of hydro thermal power system is controlled by both conventional PI and fuzzy logic controllers but the peak overshoot and settling time of fuzzy controller is less than that of conventional PI controller and this is clear from their results. The control strategies guarantees that the steady state error of frequencies and interchange of tie-lines power are maintained in a given tolerance limitations. The performances of these controllers are simulated using MATLAB/SIMULINK package.

Keywords:
Load Frequency Control (LFC), Conventional PI Controller, Fuzzy Logic Controller, Neuro-Fuzzy Controller, Interconnected Power System.

Introduction:
In an electric power system, automatic generation control (AGC) is a system for adjusting the power output of multiple generators at different power plants, in response to changes in the load. Since a power grid requires that generation and load closely balance moment by moment, frequent adjustments to the output of generators are necessary. The balance can be judged by measuring the system frequency; if it is increasing, more power is being generated than used, and all the machines in the system are accelerating. If the system frequency is decreasing, more load is on the system than the instantaneous generation can provide, and all generators are slowing down.

In order to keep the system in the steady state, both the active and the reactive powers are to be controlled. The objective of the control strategy is to generate and deliver power in an interconnected system as economically and reliably as possible while maintaining the voltage and frequency with in permissible limits. Changes in real power mainly affect the system frequency, while the reactive power is less sensitive to the changes in frequency and is mainly dependent on the changes in voltage magnitude.

Thus real and reactive powers are controlled separately. The load frequency control loop (LFC) controls the real power and frequency and the automatic voltage regulator regulates the reactive power and voltage magnitude. Load frequency control has gained importance with the growth of interconnected systems and has made the operation of the interconnected systems possible.

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In an interconnected power system, the controllers are for a particular operating condition and take care of small changes in load demand to maintain the frequency and voltage magnitude within the specified limits.

Reasons for keeping frequency constant:

The following are the reasons for keeping strict limits on the system frequency variations. The speed of AC motors is directly related to the frequency. Even though most of the AC drives are not much affected for a frequency variation of even 50±0.5Hz but there are certain applications where speeds consistency must be of higher order. The electric clocks are driven by synchronous motors and the accuracy of these clocks is not only a function of frequency error but is actually of the integral of this error. If the normal frequency is 50Hz, and the turbines are run at speeds corresponding to frequency less than 47.5Hz or more than 52.5Hz the blades of the turbine are likely to get damaged. Hence a strict limit on frequency should be maintained [1]. The system operation at sub normal frequency and voltage leads to the loss of revenue to the suppliers due to accompanying reduction in load demand .It is necessary to maintain the network frequency constant so that power stations run satisfactorily in parallel. The overall operation of power system can be better controlled if a strict limit on frequency deviation is maintained. The frequency is closely related to the real power balance in the overall network. Change in frequency [2-6], causes change in speed of the consumers' plant affecting production processes.

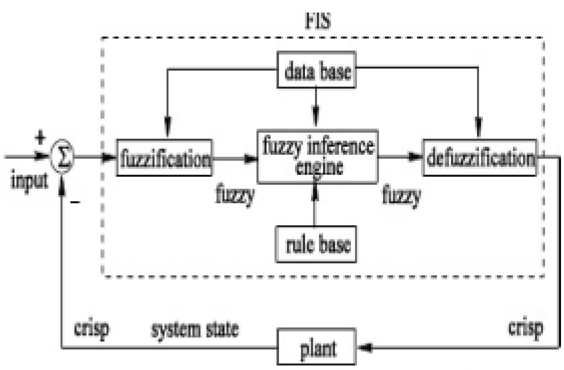


Fig : Structure of fuzzy logic controller

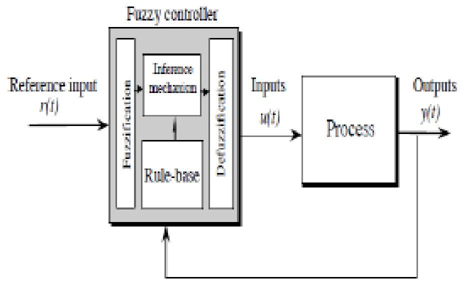


Fig.:.General Structure of the fuzzy logic controller on closed-loop system

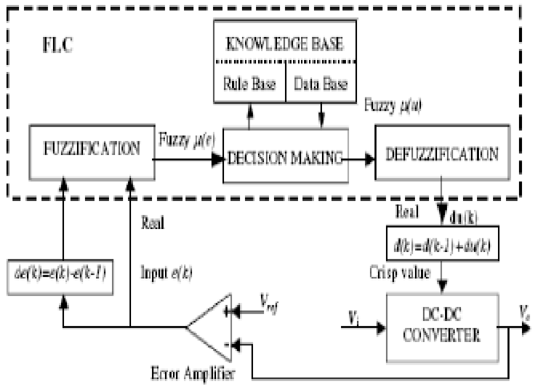
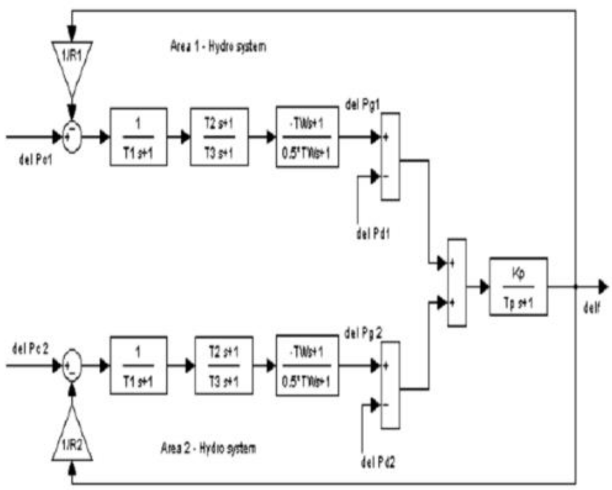


Fig.6. Block diagram of the Fuzzy Logic Controller (FLC) for dc-dc converters



Transfer model of Interconnected areas in a power system.

Table 1: Equal disturbance in both areas, $\Delta P_{d1}=0$ $\Delta P_{d2}= 0.01$ with controllers in both areas

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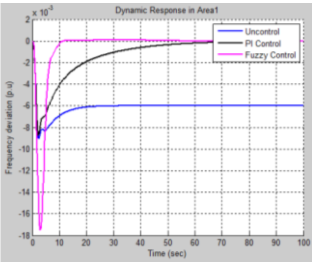
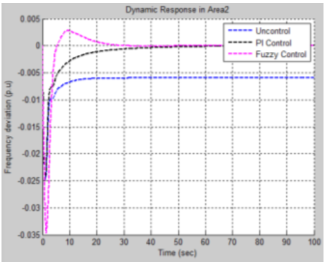
Response of area–1			
	% Over shoot	**Settling time**	**Steady state error**
Uncontrolled	–0.0089	20.70	–0.006
PI controller	–0.0087	65.52	0
Fuzzy PI controller	–0.0175	11.09	0
Response of area–2			
Uncontrolled	–0.0246	13.73	–0.0063
PI controller	–0.0247	47.44	0
Fuzzy PI controller	–0.0345	26.06	0



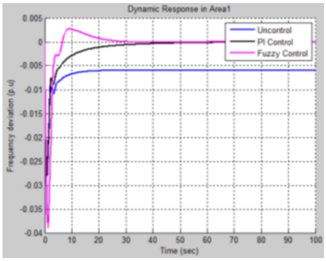
Change in frequency deviation of area1 for a load change of ΔP_{d1}= 0 & ΔP_{d2}= 0.01 with controllers in both areas



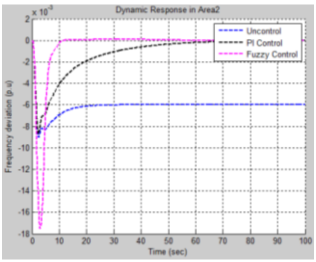
Change in frequency deviation of area2 for a load change of ΔP_{d1}= 0 & ΔP_{d2}= 0.01 with controllers in both areas

Table 2: Equal disturbance in both areas, ΔP_{d1}=0.01 ΔP_{d2}= 0 with controllers in both areas

Response of area–1			
	% Over shoot	**Settling time**	**Steady state error**
Uncontrolled	–0.0279	12.89	–0.0063
PI controller	–0.0282	46.89	0
Fuzzy PI controller	–0.0388	25.97	0
Response of area–2			
Uncontrolled	–0.0087	21.67	–0.0061
PI controller	–0.0090	68.20	0
Fuzzy PI controller	–0.0175	11.24	0



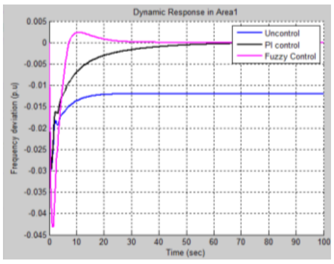
Change in frequency deviation of area1 for a load change of ΔP_{d1}= 0.01& ΔP_{d2}= 0 with controllers in both areas



Change in frequency deviation of area2 for a load change of ΔP_{d1}= 0.01& ΔP_{d2}= 0 with controllers in both areas

Table 3: Equal disturbance in both areas, ΔP_{d1}=ΔP_{d2}= 0.01 with controllers in both areas

Response of area–1			
	% Over shoot	**Settling time**	**Steady state error**
Uncontrolled	–0.0296	22.09	–0.0121
PI controller	–0.0298	54.87	0
Fuzzy PI controller	–0.0432	26.19	0
Response of area–2			
Uncontrolled	–0.0276	22.39	–0.0121
PI controller	–0.0279	55.69	0
Fuzzy PI controller	–0.0423	25.11	0



Change in frequency deviation of area1 for a load change of ΔP_{d1}= ΔP_{d2}= 0.01 with controllers in both areas

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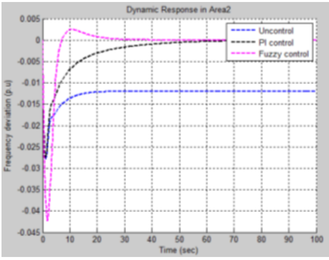
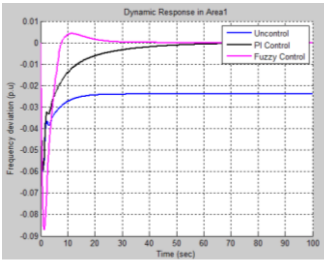


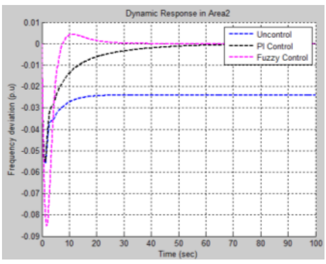
Change in frequency deviation of area2 for a load change of $\Delta P_{d1}= \Delta P_{d2}= 0.01$ with controllers in both areas

Table 5: Equal disturbance in both areas, $\Delta P_{d1}=\Delta P_{d2}= 0.02$ with controllers in both areas

Response of area–1			
	% Over shoot	**Settling time**	**Steady state error**
Uncontrolled	–0.0318	24.24	–0.0181
PI controller	–0.0398	62.98	0
Fuzzy PI controller	–0.0506	28.04	0
Response of area–2			
Uncontrolled	–0.0518	21.81	–0.0181
PI controller	–0.0516	56.51	0
Fuzzy PI controller	–0.0754	27.81	0



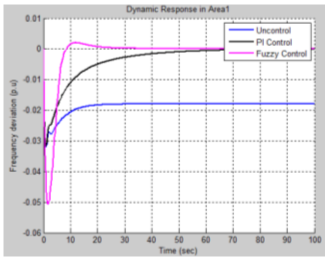
Change in frequency deviation of area1 for a load change of $\Delta P_{d1}= \Delta P_{d2}= 0.02$ with controllers in both areas



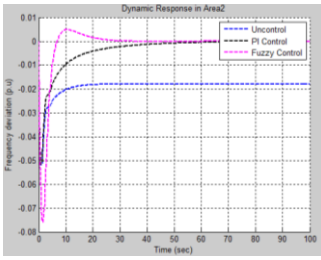
Change in frequency deviation of area2 for a load change of $\Delta P_{d1}= \Delta P_{d2}= 0.02$ with controllers in both areas

Table 6: Equal disturbance in both areas, $\Delta P_{d1}=0.01$ &$\Delta P_{d2}= 0.02$ with controllers in both areas

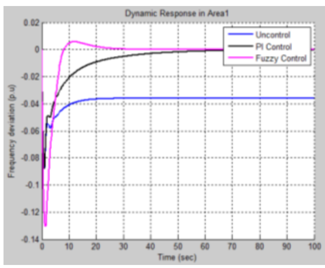
Response of area–1			
	% Over shoot	**Settling time**	**Steady state error**
Uncontrolled	–0.0594	21.72	–0.0243
PI controller	–0.0598	68.55	0
Fuzzy PI controller	–0.0871	29.11	0
Response of area–2			
Uncontrolled	–0.0551	20.45	–0.0243
PI controller	–0.0558	63.43	0
Fuzzy PI controller	–0.0851	26.56	0



Change in frequency deviation of area1 for a load change of $\Delta P_{d1}= 0.01$ &$\Delta P_{d2}= 0.02$ with controllers in both areas



Change in frequency deviation of area2 for a load change of $\Delta P_{d1}= 0.01$ &$\Delta P_{d2}= 0.02$ with controllers in both areas



Change in frequency deviation of area1 for a load change of $\Delta P_{d1}=\Delta P_{d2}= 0.03$ with controllers in both areas

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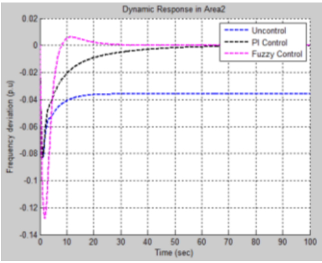
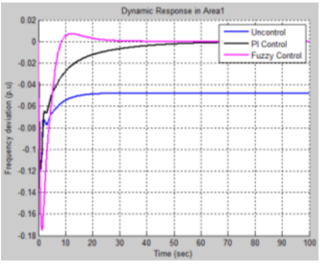
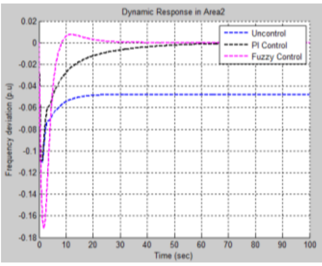


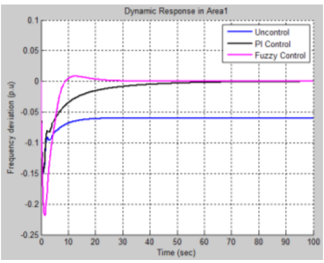
Change in frequency deviation of area2 for a load change of ΔP_{d1}=ΔP_{d2}= 0.03 with controllers in both areas



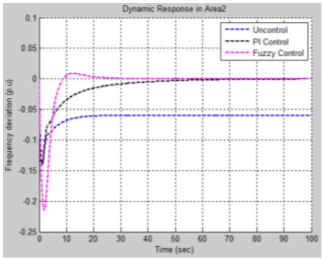
Change in frequency deviation of area1 for a load change of ΔP_{d1}=ΔP_{d2}= 0.04 with controllers in both areas



Change in frequency deviation of area2 for a load change of ΔP_{d1}=ΔP_{d2}= 0.04 with controllers in both areas



Change in frequency deviation of area1 for a load change of ΔP_{d1}=ΔP_{d2}= 0.05 with controllers in both areas



Change in frequency deviation of area2 for a load change of ΔP_{d1}=ΔP_{d2}= 0.05 with controllers in both areas

CONCLUSIONS:

In this paper a new technique fuzzy logic PI controller is designed for automatic load frequency control of interconnected power systems. The controller performances Fuzzy logic PI approach is in work for a Load Frequency Control for Generation of Interconnected Power System. From the above research it can be concluded that the transient response, settling time and peak overshoot in case of fuzzy logic controller is lesser as compared to the conventional PI controller. Thus simulation results of FLC have better control performance over conventional PI when some disturbance in load is given or loaded into the interconnected hydro-thermal power system. In short we can say that the FLC is adequate for better quality and reliable electric power supply due to less settling time, less peak overshoot and quick rise time.

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Author's Details:

Ammisetty Jayasree

M.Tech Student, QIS College of Engineering and Technology.

Sri.R.Sathish Kumar

The B.Tech. degree in Electrical & Electronics Engineering from Jawaharlal Nehru Technological University, Hyberabad, India, 2005 &M.Tech. degree in electrical & electronics engineering from Jawaharlal Nehru Technological University, Hyberabad, India, in 2010. Currently, he is an Associate Professor in QIS College of Engineering and Technology, Ongole, India. He has published a number of papers in various national & international journals & conferences. His research areas are power system operation & control and economic load dispatch.

Dr.B.Venkata Prasanth

Received the B.Tech. degree in Electrical & Electronics Engineering from *Sri* Krishnadevaraya University & M.Tech. degree in Electrical Power Systems from Jawaharlal Nehru Technological University, Ananthapur, India. He received his Ph.D. degree in Electrical & Electronics Engineering from Jawaharlal Nehru Technological University, Hyderabad, India. He has got a teaching experience of more than 14 years. Currently, he is working as Professor & Head in QIS College of Engineering and Technology, Ongole, India in the Dept. of Electrical & Electronics Engineering. He has published a number of papers in various national & international journals & conferences. He is also guiding a number of research scholars in various topics of electrical engineering. His research interests include application of intelligent controllers to power system control design, power system restructuring, power system economics & optimization.