Comparisons of various controllers in Load Frequency Control of Power Grid with Multi Source Power Generation

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ABSTRACT: *Load frequency control is a virtual challenging problem in a realistic complex power system network. Power demand on the grid is unpredictably varying in nature and consequently grid frequency also varies. To alleviate frequency fluctuations on the grid, the renewable energy resources are interfaced with the grid. Renewable resources are abundant and eco-friendly, but the power generation from these sources is intermittent in nature. To provide major contribution of power generation from the renewable energy resources and to reduce cost of unit power generation in control areas, an effective controller is required. Application of an advanced intelligent controller (FUZZY, ANFIS) improve the performance of load frequency control by reducing the frequency deviations. The steady state error and settling time shows the satisfactory performance of the prescribed controller.*

INTRODUCTION:

The successful operation of interconnected power systems requires the matching of total generation with total load demand and associated system losses. With time, the operating point of a power system changes, and hence systems may experience deviations in nominal system frequency and scheduled power exchanges to other area, which may yield undesirable effects. To maintain load frequency with in the desirable limits various controlling strategies like classical methods, adaptive and variable structure methods, robust control approaches, intelligent techniques and digital control schemes are available. Various factors affect the system frequency like generation rate constraints, speed governing techniques, load disturbances [1-2]. Load frequency control is a wide problem so, to provide better controlling aspects the system fragmented as a control areas. The control areas have group of generating stations or generating units. In such a control area the power generating plants are alike or different. Generally same plants are grouped for easy controlling. Different plants can be grouped in a single area. The control area maintain the frequency with in the permissible limits by generating required amount of power to meet power demand at every instant of time. The control areas are inter connected with the tie-lines. To exchange power from one area to another area, to operate generating stations most economical manner, to enhance power system stability. The power exchange between controlling areas are based on their contracts and other power generation constraints [3-5]. Control area having different power generating sources like thermal, hydro, diesel, gas, and nuclear plants [6-7]. Generally thermal plants are operated as base load plants. These plants continuously running irrespective of load demand. Due to some faults in the power system the frequency vary larger otherwise the frequency variations with in the acceptable limits [8]. The hydro plants are operated as both peak and base load plants depending upon water availability, plant capacity and load demand [9]. Gas and diesel plants are operated as peak load plants. The integration of these plants with grid is complex due to different factors affect the individual plant performances. The frequency controlling also complex. For short span of load disturbances the energy storage systems are helpful to meet the power demand. The energy systems like SMES, BES, CES, and RFB have been used in load frequency control systems [6]. In conventional methods PI controller is used to limit the area control error and to improve the dynamic performance of the system. The FGPI (fuzzy gain PI) controller is widely used to enhance dynamic performance [10]. The new trend concentrating on renewable power generation and integration of grid with this renewable plants. As intermittency of renewable sources makes frequency and voltage control more difficult, short and long term storage plants for electric energy must be relied on to compensate. Due to intermittent nature of power generation, the inter connection of grid with this plants become difficult. For the short distances the renewable generation is most economical. The areas consisting wind power plant, short term storage plant associated with wind power plant, natural fired gas plant, long term storage plant, photovoltaic plant, short term storage plant associated with PV plant [11].

By recent technologies like artificial intelligence techniques and advanced algorithms the integration of grid process become easier. Neural networks, fuzzy inference systems, ANFIS models [12], particle swarm optimization algorithms [13-14], Optimal control methods are used to design the output feedback controller. The optimal feedback controller is applied to two area, optimal quadratic regulators [15-16], optimal feedback controllers [6] are used to control the grid frequency. Distributed generations DG's are coming into operation to share the load demand. Renewable sources are grouped under DG's category. Wind power generation most rapidly growing in throughout the world [17-18]. In interconnected systems the fluctuations in the frequency and voltage leads to outages of lines and generators tend to cascade tripping of lines [19].

The operating point and system parameters are dynamically vary with the frequency. The FUZZY, ANN and ANFIS have best tracking ability of system parameters to optimize frequency fluctuations [20]. The ANFIS controller having self-tuning capability of system parameters and possess advantages of ANN and fuzzy. The fuzzy theory useful to represent the system behaviour with simple linguistic rules, the neural network optimize the parameters [21-22].

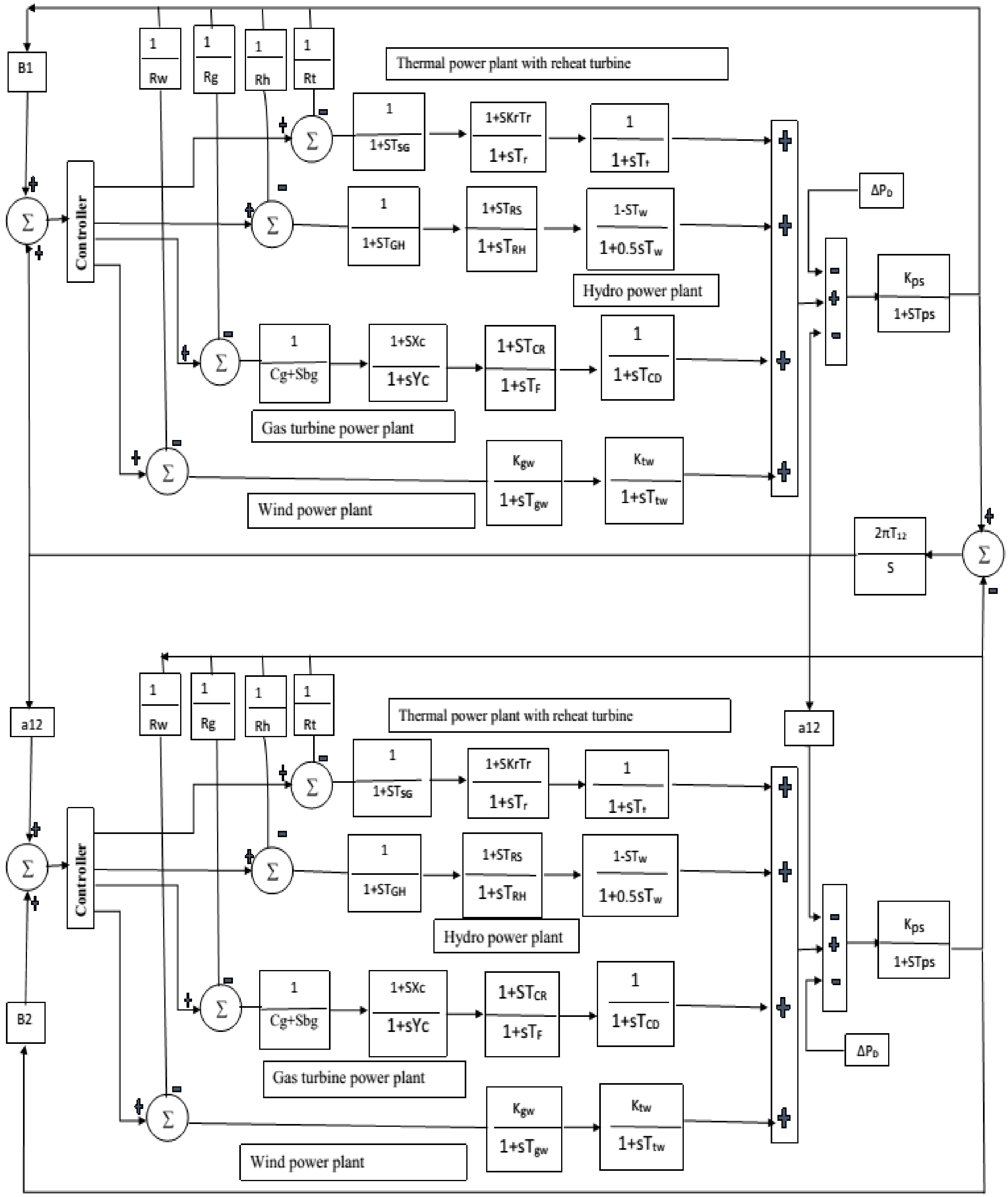

Figure 1: Transfer function model of multi-source two area system

ARTIFICIAL INTELLIGENT CONTROLLERS:

FUZZY, ANFIS, Online fuzzy gain tuner controllers extensively using in all fields to resolve the realistic complex problems. The controllers having this future simple realistic rules perform better control action than PI and PID controllers.

Fuzzy derived from fundamental classical set theory. The fuzzy controller mainly have fuzzification block, fuzzy rule base, defuzzification block. The crisp signals are converted into fuzzy membership functions by the fuzzification process. Membership functions are performed based on the fuzzy rule base and produce fuzzified values to the defuzzification block. This block converts fuzzified values into crisp values by the defuzzification process. This is the controller output which is given to the plant to perform the control action.

FUZZY CONTROLLER:

Fuzzy controller have two inputs and single output. The inputs are area controller error (ACE) and change in area control error (ΔACE). Each input having 7 trapezoidal membership functions are NB (Negative Big), NM (Negative Medium), NS (Negative Small), Z (Zero), PS (Positive Small), PM (Positive Medium), PB (Positive Big). The sugeno rule base adopted here and the defuzzification process is centroid method. The fuzzy rules are shown below.

$E/_{\Delta E}$	NB	NM	NS	Z	PS	PM	PB
NB	NB	NM	NB	NB	NM	NS	Z
NM	NB	NM	NM	NM	NS	Z	PS
NS	NB	NM	NS	NS	Z	PS	PM
Z	NB	NM	NS	Z	PS	PM	PB
PS	NM	NS	Z	PS	PS	PM	PB
PM	NS	Z	PS	PM	PM	PM	PB
PB	Z	PS	PM	PB	PB	PB	PB

Table: 1 Fuzzy Rule Base

ANFIS CONTROLLER:

Adaptive neuro fuzzy system controller having features of both neural networks and fuzzy inference systems. The controller having unique feature is that controller can generate the FIS file according to our requirement. This will provide finite optimum tracking operating point to the system. The controller has two inputs area control error (ACE) and change in area control error (ΔACE). Each input having 11 trapezoidal membership functions and 11^2 output membership functions.

ANFIS controller FIS structure is designed based on the values of area control error (ACE) and change in area control error (ACE) at different loading conditions. 11 trapezoidal membership functions are chosen for each input. The training data given to controller and trained then it generate the sugeno rule base with optimum output range. The rules are framed according to our training data. Figure 2 reveals the Anfis rules.

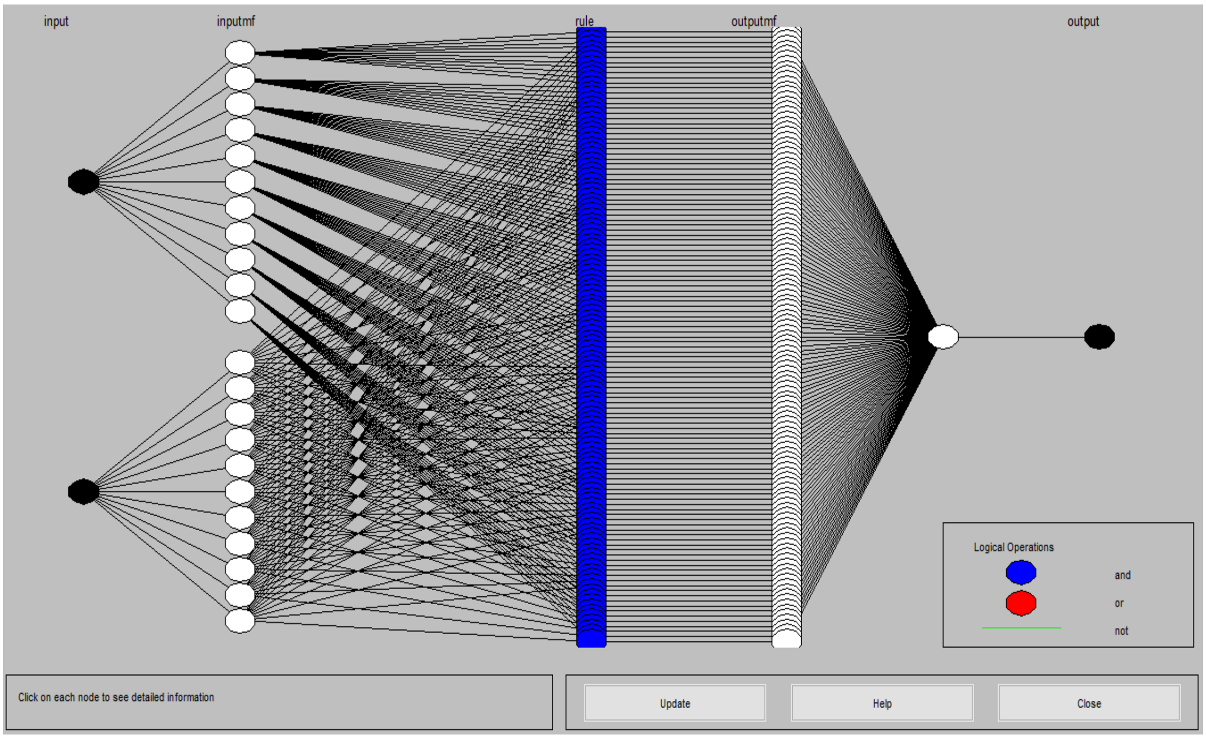

Figure 2: Anfis Rule Base Structure

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SIMULATION AND RESULTS:

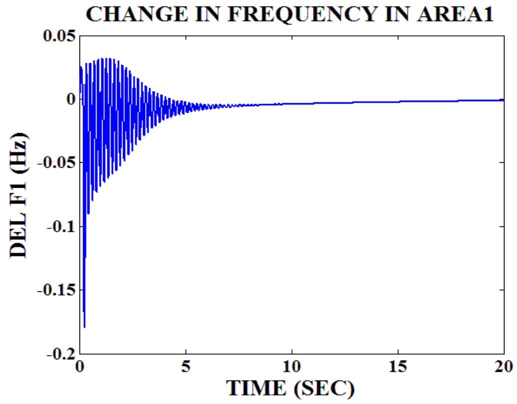

Figure 3: Change in frequency in area1 with ANFIS controller 20%, 30% loading.

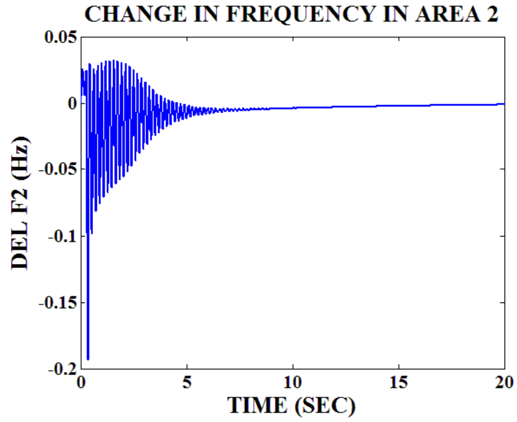

Figure 4: change in frequency in area 2 with ANFIS controller 20%, 30% loadding.

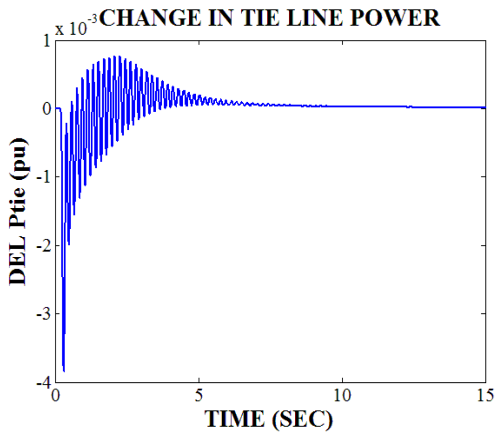

Figure 5: change in tie line power with ANFIS controller 20%, 30% loading.

Figures 3, 4&5 gives information the control areas 1 & 2 are loaded at 20%, 30% respectively. The frequency changes in respective areas, change in tie line power is shown. ANFIS controller give lesser settling time.

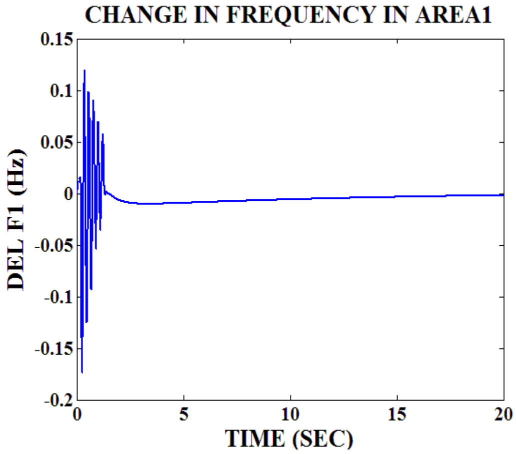

Figure 6: change in frequency in area1 with FUZZY controller 20%, 30% loading.

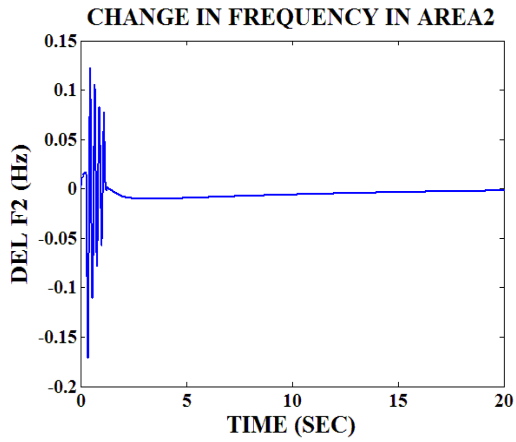

Figure 7: change in frequency in area2 with FUZZY controller 20%, 30% loading.

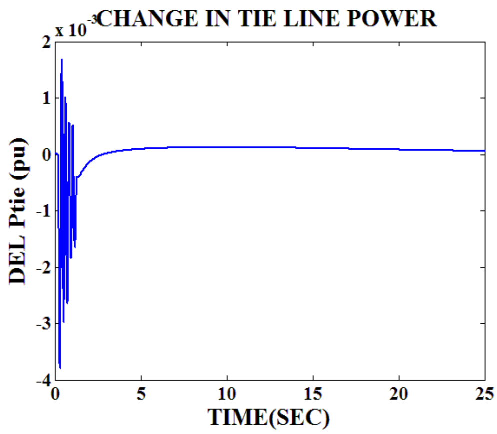

Figure 8: change in tie line power with FUZZY controller 20%, 30% loading.

Figures 6, 7&8 gives information the control areas 1 & 2 are loaded at 20%, 30% respectively. The frequency changes in respective areas, change in tie line power is shown. FUZZY controller give satisfactory settling time.

Table: 2 Area1 Frequency Deviation

Controller	Rise Time (Sec)	Peak Time (Sec)	Settling Time (Sec)
FUZZY	0.0063	0.2555	15.9973
ANFIS	0.0025	0.2579	11.3699

Table: 3 Area2 Frequency Deviation

Controller	Rise Time (Sec)	Peak Time (Sec)	Settling Time (Sec)
FUZZY	0.0064	0.3509	16.1381
ANFIS	0.0025	0.3619	10.5533

Table: 4 Tie Line Power Deviation

Controller	Rise Time (Sec)	Peak Time (Sec)	Settling Time (Sec)
FUZZY	2.25e-04	0.3125	13.524
ANFIS	2.252e-04	0.3099	6.7179

Tables 2, 3 & 4 shows comparison of control area1 frequency, control area2 frequency and tie line power with fuzzy and Anfis controller at 20%, 30% loading on the respective control areas. The Anfis controller reduce the settling time compare to Fuzzy controller. This reveals finite settling of frequencies with zero steady state error. Comparison:

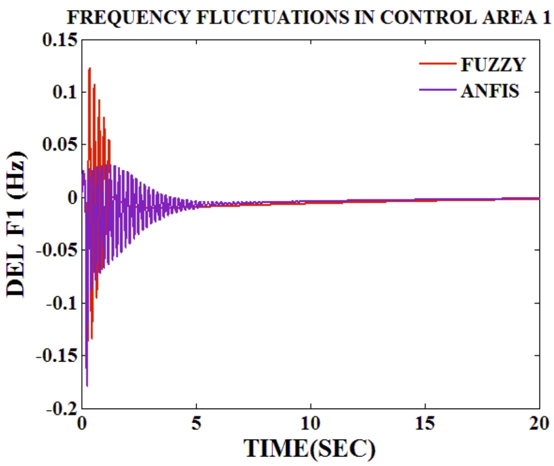

Figure 9: Frequency variations in area1 with 20%, 30% loading in control areas1 & 2 with FUZZY and ANFIS controllers.

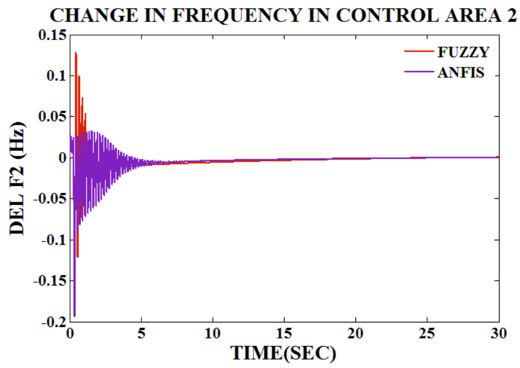

Figure 10: Frequency variations in area1 with 20%, 30% loading in control areas1 & 2 with FUZZY and ANFIS controllers.

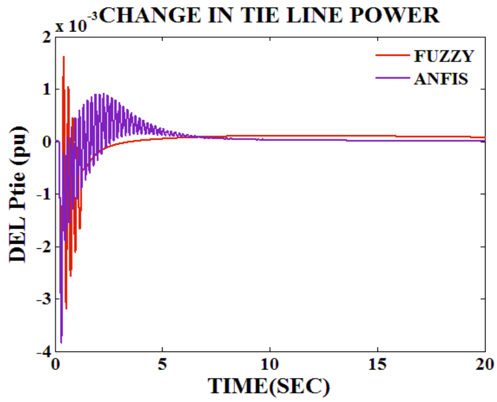

Figure 11: Change in tie line power with 20%, 30% loading in control areas1 & 2 with ANFIS & FUZZY controllers.

Figures 9, 8 & 10 shows comparison of control area frequency deviations and tie line power variations with Fuzzy and Anfis controller.

Control areas 1 & 2 are loaded 20%, 30% respectively. The graphs emphasis change in tie line powers settling time of prescribed controllers. ANFIS controller provides quick settling time, comparative overshoot compare to FUZZY controller. ANFIS provides zero steady state error.

CONCLUSION:

In this paper, perceived that the dynamic performance of multi-source power generation Load frequency control achieved by employing FUZZY controller, ANFIS controller. The performance evaluation shows that both controllers provides satisfactory control of frequency, tie line power. Artificial intelligent controllers have wider adaptability of power plant environment. The effectiveness of ANFIS controller provides better controlling action. The comparison shows that Anfis controller gives lesser settling time with zero steady state error. ANFIS controller improves the dynamic performance of the two area multi source power system.

REFERENCES:

[1]. Shayeghi, H. A. Shayanfar, and A. Jalil "Automatic generation control strategies a state- of-the-art survey for the researcher," ISBN: 978-1-61122-759-8, 2011.

[2]. Ibrheem, Prabhat Kumar, and Dwarka P. Kothari "Recent Philosophies of Automatic Generation Control Strategies in Power Systems" IEEE transactions on power systems, vol. 20, no. 1, February 2005.

[3]. D. P. Kothari, I. J. Nagrath, "Modern power system analysis," 3rd ed., Singapore McGraw-Hill, 2003.

[4]. P. Kundur, Power System Stability and Control. New York: McGrawHill, 1994.

[5]. P.M Anderson, A.A Fouad "Power system control and stability".

[6]. K.P. Singh parmar, S. Majhi, D.P. Kothari "Load frequency control of a realistic power system with multi-source power generation," Electrical Power and Energy Systems 42 (2012) 426–433.

[7]. K.P. Singh parmar "Load frequency control of multi-source power system with redox flow batteries," International Journal of Computer Applications (0975-8887), volume 88 – No.8, February 2014.

[8]. Yuksel OGUZ "Fuzzy PI control with parallel fuzzy PD control for automatic generation control of a two-area power systems," GUJS24 (4):805-806 (2011).

[9]. S. Doolla, T.S. Bhatti "Automatic generation control of an isolated small-hydro power plant," electric power system research 76 (2006) 889-896.

[10]. Ertugrul CAM Ilhan Kocaarslan "Load frequency control in two are power system," TEKNOLOJI, volume 7, (2004), Issue 2, 197-203.

[11]. W.L. Fuchs, and E.F. Fuchs "Frequency variations of power system due to switching of renewable energy sources," International Conference on Renewable Energies and Power Quality (ICREPQ'12), March 2012.

[12]. K. Harinath Reddy "Study and analysis of LFC with wind plant in two area power system through fuzzy inference technique," ISSN: 2278-3075, volume-4 issue-7, December 2014.

[13]. Haluk GOZDE, M. cengiz TAPLAMACIOGLU, Ilhan KOCAARSLAN, Ertugrul CAM "Particle swarm optimization based load frequency control in a single area power system," , ISSN-1453-1119, 2008.

[14]. K.P. Singh Parmar "PSO based PI controller for the LFC system of an interconnected power system," international journal of computer applications, volume 88-No.7, February 2014.

[15]. K.P. Singh Parmar, S. Majhi, D.P. Kothari "Optimal load frequency control of an interconnected power system," MIT International Journal of Electrical and Instrumentation Engineering vol.1, January 2011.

[16]. E. Rakhshani and j. Sadeh "Load frequency control of multi-area restructured power system," 978-1-4244-1762-9/08, IEEE 2008.

[17]. A. Chatterjee, S.P. ghoshal and V. Mukherjee "Transient performance improvement of thermal system connected to grid using distributed generation and capacitive energy storage unit," International Journal on Electrical Engineering and Informatics – vol 2, November 3, 2010.

[18]. Dulal Ch Das, A.K. Roy, N. Sinha "PSO optimized frequency controller for wind-solar thermal-diesel hybrid energy generation system," International Journal of Wisdom Based Computing, vol1 (3), December 2011.

[19]. Wood, B. Wollenberg, Power generation control and operation, 2nd ed., John Wiley and Sons, 1996.

[20]. K.V. Siva Reddy "An Adaptive Neuro-Fuzzy Logic Controller for a Two Area Load Frequency Control," IJERA, ISSN: 2248-9622, Vol. 3, Issue 4, and Jul-Aug 2013.

[21]. T. Bharath kumar & M. Uma vani "Load frequency control in two area power system using ANFIS," International Journal of Electrical and Electronics Engineering Research (IJEEER) ISSN (P): 2250-155X, ISSN (E): 2278-943X, Vol. 4, Issue 1, Feb 2014, 85-92.

[22]. CH. Ravi Kumar and Dr. P. R. Ramana Rao"Application Of Hybrid Neuro Fuzzy Controller For Automatic Generation Control Of Three Area Power System Considering Parametric Uncertainties," International Journal Of Electrical Engineering & Technology (IJEET) ISSN 0976 – 6545(Print) ISSN 0976 – 6553(Online) Volume 4, Issue 5, September – October (2013), pp. 104-114.

BIOGRAPHIES

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