International Journal of Current Engineering and Technology
ISSN 2277 - 4106

Research Article

A Simulation Model for LFC using Fuzzy PID with Interconnected Hydro power Systems

Ramanand Kashyap[Ȧ*] and S.S. Sankeswari[Ȧ]

[Ȧ]PG. Dept. College of Engg. Ambajogai.

Accepted 12 March 2014, Available online 01 April 2014, **Special Issue-3, (April 2014)**

Abstract

In this paper, load frequency control (LFC) of power system with two source hydro power generation is presented. The main objective of Automatic Generation Control (AGC) is to balance the total system generation against system load losses so that the desired frequency and power interchange with neighbouring systems is maintained. Any mismatch between generation and demand causes the system frequency to deviate from its nominal value. Thus high frequency deviation may lead to system collapse. This necessitates a very fast and accurate controller to maintain the nominal system frequency. This paper deals with load frequency control of an interconnected two area hydro-hydro system. The system is incorporated with conventional proportional-integral (PI) and fuzzy logic controller (FLC). We are assuming that all areas in a system operate at the same frequency because the traditional approach for interconnection turned out to be unsuccessful for hydro-hydro systems. Time domain simulation is used to study the performance, when a 0.5% step load disturbance is given in area of the system. Finally the simulation results of conventional PI controller is compared with fuzzy logic PID controller and proved that FLC yields better control performance.

Keywords: *LFC power system , conventional controller fuzzy controller & Fuzzy PID , Simulation result*

1. Introduction

Load-frequency control (LFC) issue in power systems has a long history and its literature is huge. The preliminary LFC schemes have evolved over the past decades, and interest continues in proposing new intelligent LFC approaches with an improved ability to maintain tie-line power flow and system frequency close to specie values. In case of a hydro power, the power system frequency regulation can be affected due to water flow fluctuation. This leads to imbalance between power generation and power demand, and as a result, frequency will deviate from its nominal value. Significant frequency deviations may cause under/over frequency relay operations and finale disconnect some parts of system loads and generations. The impact of hydro power generation on system frequency response and LFC mechanism.

The conventional LFC designs are usually suitable for working at specific operating points, and they are not more efficient for modern power systems, considering increasing size, changing structure, emerging renewable energy sources, and new uncertainties. Most of conventional LFC creation methodologies provide model-based controllers that are difficult to use for large-scale power systems with nonlinearities, and uncertain parameters. Over the years, several Conventional control techniques are used for the frequency regulation / LFC issue in the power systems; however, there are just few reports on the intelligent frequency control design in the presence of hydro power units.

Recently, fuzzy logic because of simplicity, robustness, and reliability is used in almost all fields of science and technology, including solving a wide range of control problems in power system control and operation. The fuzzy control methodology tries to establish the controller directly based on the measurements, long-term experiences, and the knowledge of domain experts/operators. This paper presents the performance of two area interconnected hydro-hydro system with conventional PI and fuzzy logic controller. The conventional PI control strategy does not give adequate control performance when a 0.5% step load disturbance is given in area of the system. Therefore an optimum fuzzy logic controller has been proposed in this paper. The difficulty in obtaining the optimum settling time of previously said controller is mitigated by using FLC. Simulation results confirm that the fuzzy logic controller greatly reduces the overshoots. The settling time is also reduced considerably.

2 Load Frequency Control

Modern day power systems are divided into various areas. For example in India, there are five regional grids, e.g.,

*Corresponding author: Ramanand Kashyap

Eastern Region, Western Region etc. Each of these areas is generally interconnected to its neighboring areas. The transmission lines that connect an area to its neighboring area are called tie-lines. Power sharing between two areas occurs through these tie-lines. Load frequency control, as the name signifies, regulates the power flow between different areas while holding the frequency constant.

As we have in following example that the system frequency rises when the load decreases if ΔP_{ref} is kept at zero. Similarly the frequency may drop if the load increases. However it is desirable to maintain the frequency constant such that $\Delta f=0$. The power flow through different tie-lines are scheduled - for example, area- i may export a pre-specified amount of power to area- j while importing another pre-specified amount of power from area- k . However it is expected that to fulfill this obligation, area- i absorbs its own load change, i.e., increase generation to supply extra load in the area or decrease generation when the load demand in the area has reduced. While doing this area- i must however maintain its obligation to areas j and k as far as importing and exporting power is concerned. A conceptual diagram of the interconnected areas is shown in Figure 1.

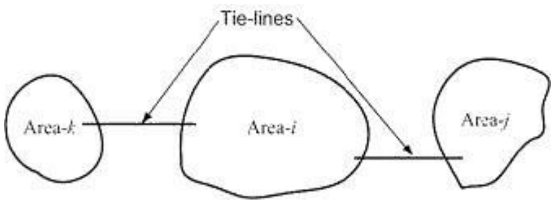

Figure 1 Interconnected areas in a power system.

We can therefore state that the load frequency control (LFC) has the following two objectives:

- Hold the frequency constant ($\Delta f = 0$) against any load change. Each area must contribute to absorb any load change such that frequency does not deviate.
- Each area must maintain the tie-line power flow to its pre-specified value. The first step in the LFC is to form the **area control error (ACE)** that is defined as

$$\text{ACE} = (P_{tie} - P_{sch}) + B_f \Delta f = \Delta P_{tie} + B_f \Delta f \qquad (1)$$

where P_{tie} and P_{sch} are tie-line power and scheduled power through tie-line respectively and the constant B_f is called the frequency bias constant .

The change in the reference of the power setting $\Delta P_{ref, i}$, of the area- i is then obtained by the feedback of the ACE through an integral controller of the form

$$\Delta P_{ref,i} = -K_i \int \text{ACE}\, dt \qquad (2)$$

where K_i is the integral gain. The ACE is negative if the net power flow out of an area is low or if the frequency has dropped or both. In this case the generation must be increased. This can be achieved by increasing $\Delta P_{ref, i}$. This negative sign accounts for this inverse relation between $\Delta P_{ref, i}$ and ACE. The tie-line power flow and frequency of each area are monitored in its control center. Once the ACE is computed and $\Delta P_{ref, i}$ is obtained from (1), commands are given to various turbine-generator controls to adjust their reference power settings.

3 Power System

A block diagrams of two area interconnected power systems for the uncontrolled & nonlinearites is shown in figure 2. In the diagrams, the frequency (system frequency common to all areas) is determined by integrating the net system accelerating/decelerating power (i.e. difference of total system generation and load). Since the difference between the area frequencies is neglected, the traditional approach cannot be used to compute the tie line flow deviations. In order to obtain the tie line flows the area power balance equations has been used. The power balance equation for the ith area is written as

$$P_{tie} + P_{gi} - P_{di} = H_i \frac{d(f)}{dt} \qquad (3)$$

where Ptie is the tie line power flow, Pgi is the area generation of i th area, Pdi is the ith area load disturbance, Hi is the inertia constant of ith area and f is the system frequency. The Purpose of all AGC is the frequency used for one area to compute ACE should be the same as used in the other areas so long as they remain interconnected.

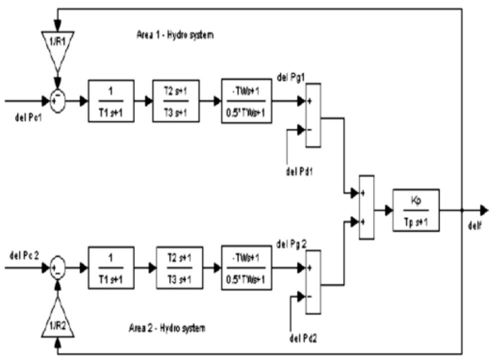

Figure 2 Transfer model of Interconnected areas in a power system.

4 Control Methodology

4.1 PI Controller

One the most widely used control for using the power systems . Proportional controller is used get to the steady state condition much quicker.The controller produce a control signal proportional to the error in the system. Integrator tends to increase control action, thus driving the plant out put towards the demand output. The control signal can be written as,

$$u_1 = -K_p \cdot ACE_1 - K_i \int ACE_1 dt \qquad (4)$$

$$u_2 = -K_p \cdot ACE_2 - K_i \int ACE_2 dt \qquad (5)$$

where Kp and Ki are proportional and integral controller gain respectively. To find the optimum value of the conventional Kp and Ki, integral square error (ISE) criterion has been used. For ISE technique the objective function used is,

$$J = \int_0^{\infty} ACE^2 \, dt \tag{6}$$

The optimum value of Kp and Ki are found to be 0.004 and 0.03 respectively, using (5). Fig. 4(a)-(d) shows the responses of hydro-hydro system with PI controller. In this Fig. 5(a)-(d) shows the responses it is clear that the over shoot is high and not to settle down quick. That causes we are developing new controller .

4.2 Fuzzy controller

Fuzzy logic is a problem solving control technique in control system engineering. The concept of fuzzy logic was developed by Zadeh in 1965. The 1st fuzzy controller developed by Mamdani and Pappis in 1977, was steam engine controller and later fuzzy traffic lights.

The FLCS design can be normally divided in to three areas namely allocation of area of inputs, determination of rules and defuzzifying of outputs into a real value[7]. In this study the proposed fuzzy controller takes the input as ACE and ACĖ, which is given in (1).

The block diagram of fuzzy logic controller is shown in Figure 3. Membership Functions (MF) specifies the degree to which a given input belongs to set. Here, seven membership function have been used to explore best settling time namely, Negative Big (NB), Negative Medium (NM), Negative Small (NS), Zero (ZO), Positive Small (PS), Positive Medium (PM) and Positive Big (PB).

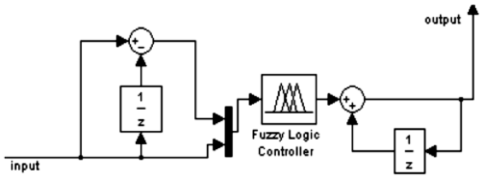

Fig. 3 Fuzzy Logic Controller

Fuzzy rules are conditional statement that specifies the relationship among fuzzy variables. These rules help us to describe the control action in quantitative terms and have been obtained by examining the output response to corresponding inputs to the fuzzy controller. Rules are given in Table I. The rules are interpreted as follows,[10]

If ACE is NB and ACĖ is NS then output is PM

Table 1 Fuzzy rules

		ACE						
		NB	NM	NS	ZO	PS	PM	PB
ACĖ	NB	PB	PB	PB	PB	PM	PM	PS
	NM	PB	PM	PM	PM	PS	PS	PS
	NS	PM	PM	PS	PS	PS	PS	ZO
	ZO	NS	NS	NS	ZO	PS	PS	PS
	PS	ZO	NS	NS	NS	NS	NM	NM
	PM	NS	NS	NM	NM	NM	NB	NB
	PB	NS	NM	NB	NB	NB	NB	NB

5 Simulation and Results

Performed simulations using PI and fuzzy controllers applied to a two area interconnected power systems. The developed system is simulated with 0.5% step load disturbance in area. Due to this the change in dynamic responses of the system has been observed, as shown in Fig. 4(a)-(d). It is examine from the output responses that the proposed FLC is stable and less oscillations and the settling time also improved considerably. Also this output justified that this interconnection is valid for hydro hydro systems. For conventional PI controller and fuzzy logic controller, the main objective is to minimize the ACE for better control performance, as given in (1). Referring Fig. 4(c)-(d) that ACE (for both the area) is minimized considerably with fuzzy logic controller which in turn tells good control performance.

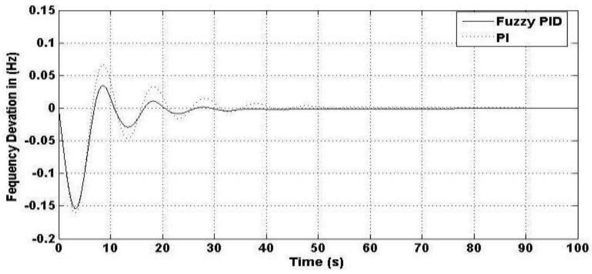

Figure 4(a) Controller with Del F

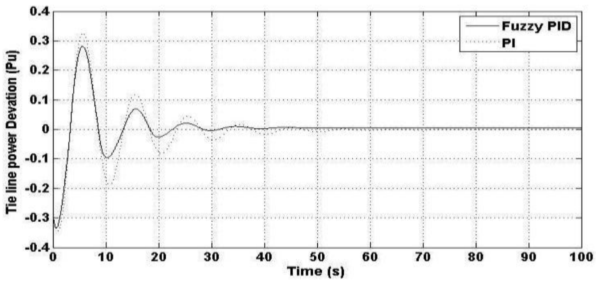

Figure 4(b) Controller with Del Tie line

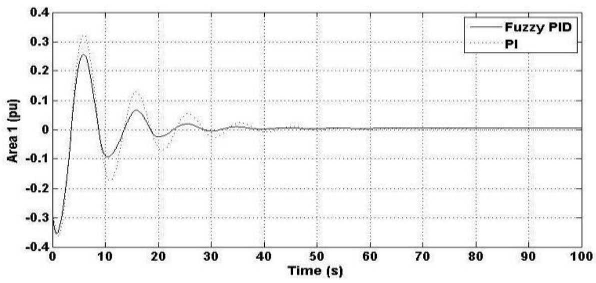

Figure 4(c) Controller with ACE 1

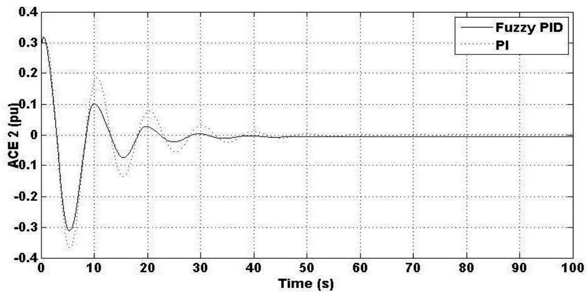

Figure 4(d) Controller with ACE 2

Conclusion

With 0.5% load variation in power system the following results are obtained. The conventional (PI) and Intelligent control approach (Fuzzy Controller) with inclusion of slider gain provides better dynamic performance and reduces the oscillation of the frequency deviation and the tie line power flow in each area in hydro-hydro combination of area interconnected power system.

Table 2 Compare

Controllers	Δf (sec)	ΔP tie (sec)	Area 1 (sec)	Area 2 (sec)
PI	65	70	70	70
Fuzzy PID	40	45	45	45

Form the above table 2 it is clear that responses obtained, reveals that Fuzzy PID controller with sliding gain provides better settling performance than PI. Therefore, the intelligent control approach using Fuzzy concept is more accurate and faster than the conventional PI control scheme even for complex dynamical system.

Appendix

Data for interconnected hydro-hydro system
Pr1 = Pr2 = 2000 MW
Kp = 120 Hz/pu MW
Tp = 20s
T1 = 48.75s
T2 = 5s
T3 = 0.513s
Tw = 1s
H = 5s
B1 = B2 = 0.425 pu MW/Hz
R1 = R2 = 2.4Hz/pu MW

References

K.C.Divya and P.S.Nagendra Rao, A simulation model for AGC studies of hydro-hydro systems, *Electrical Power and Energy Systems*, vol. 27, pp. 335-342, 2005.

O.I.Elgerd, *Electric Energy Systems Theory: An Introduction*, Mc- Graw Hill, New York, 1983.

Janardan Nanda, Ashish Mangla and Sanjay Suri, Some new findings on automatic generation control of an interconnected hydrothermal system with conventional controllers, *IEEE Transactions on Energy Conversion*, vol.21, No. 1, pp. 187-193, March 2006.

J.Nanda and A.Mangla, Automatic generation control of an interconnected hydro-thermal system using conventional Integral and fuzzy logic controller, *2004 IEEE International Conference on Electric Utility Deregulation, Restructuring and Power Technologies, Hongkong*, pp. 372-377, April 2004.

S.C.Tripathy, R.Balasubramanian and P.S.Chandramohanan Nair, Effect of superconducting magnetic energy storage on automatic generation control considering governor deadband and boiler dynamics, *IEEE Transactions on Power Systems*, Vol.7, No.3, pp. 1266–1272, August 1992.

IEEE Committee report, Dynamic models for steam and hydro turbines in power system studies, *IEEE Trans. on Power Apparatus and Systems*, Vol. 92, No. 4, pp. 1904-1911, 1973.

G.A.Chown and R.C.Hartman, Design and Experience with a fuzzy logic controller for automatic generation control *IEEE Trans. On Power Systems*, Vol.13, No.3, pp. 965-970, August 1998.

Nathan Cohn, Some aspects of tie-line bias control on interconnected power systems, *AIEE Trans*, Vol. 75, pp. 1415-1436, February 1957.

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

B.Anand and A. Ebenezer Jeyakumar , *Load Frequency Control of Interconnected Hydro-Hydro System with Fuzzy Logic Controller''*, 2011 IEEE