RESEARCH ARTICLE OPEN ACCESS

Stability Analysis of Controlled Two Area System Using Fgpi Controller

G. Shiny Vikram, V. N. Srihari Relangi, N. Venkata Ramana
Dept. of Electrical & Electronics Engineering Swarnandhra Institute of Engineering & Technology Seetharampuram, Narsapur-534280 W.G.Dt,A.P
Dept. of Electrical & Electronics Engineering Swarnandhra Institute of Engineering & Technology Seetharampuram, Narsapur-534280 W.G.Dt,A.P
Dept. of Electrical & Electronics Engineering Swarnandhra Institute of Engineering & Technology Seetharampuram, Narsapur-534280 W.G.Dt,A.P

Abstract
The dynamic behavior of power system depends up on disturbances and on changes in the operating point. In interconnected large power systems, variations in frequency can lead to serious large scale stability problems. Load characteristics, unexpected changes in power demand and faults also affect the stability. Load frequency control (LFC) is one of the major requirements in providing reliable and quality operation in multi-area power system. Conventional PID control schemes will not reach a high performance. A gain scheduling controller can be used for nonlinear systems. Some fuzzy gain scheduling of PI controllers have been proposed to solve such problems in power systems and who developed different fuzzy rules for the proportional and integral gains separately.
***Index Terms*—**LFC, ACE, FGPI etc.,

I. INTRODUCTION

As the electric power industry has evolved over the last century. Different forms of instability have emerged as being important during different periods The dynamic behavior of power system depends up on disturbances and on changes in the operating point. Since they consist of many generating units and many loads and also their total power demands vary continuously throughout a day, controlling them is very difficult. In interconnected large power systems, variations in frequency can lead to serious large scale stability problems. Load characteristics, unexpected changes in power demand and faults also affect the stability. Load frequency control (LFC) [1] is one of the major requirements in providing reliable and quality operation in multi-area power system.

Therefore, designing load frequency controllers has received great attention of researchers in recent years, and many control strategies have been developed. LFC is to regulate a signal called area control error (ACE) Conventional LFC uses a feedback signal that is based on the integral (I) of the ACE or is based on the ACE and its integral (proportional integral, or PI) type controller. These feedback signals are used to maneuver the turbine governor set points of the Generators so that the generated power follows the load fluctuations. The FGPI controller was used for the proposed control strategy, which is still widely used nowadays in industry. A linear model is written by linearising the differential equations describing the dynamic performance of the power system around an operating point. Conventional PID control schemes [2], [3] will not reach a high performance a gain scheduling controller can be used for nonlinear systems. In this method, control parameters can be changed very quickly because parameter estimation is not required. It is easier to realize as compared with automatic tuning or adaptation of controller parameters.

II. LOAD FREQUENCY CONTROL

Load frequency control, as the name signifies, regulates the power flow between different areas while holding the frequency constant. A charge in real power demand at one point of a network is reflected throughout the system by a charge in frequency. Any short term energy imbalance will result in an instantaneous change in system frequency as the disturbance is initially offset frequently changing power transfer patterns causes new stability problems. Different ownership of generation, transmission and distribution makes power system control more difficult.

In the last two decades, many studies have focused on damping control and voltage stability and related issues .However, there has been much less work on power system frequency control analysis and synthesis. The frequency of a power system is dependent on real power balance.

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 Fig. 1

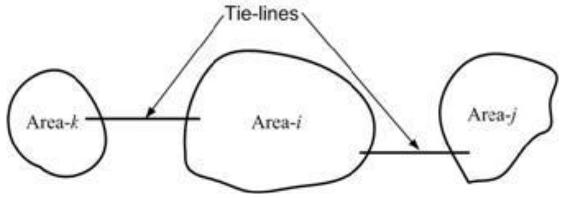


Fig.1 Interconnected areas in a power system.

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.

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

The first step in the LFC is to form the area control error (ACE) that is defined as 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 theeedback of the ACE through an integral controller of the form

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

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 (2), commands are given to various turbine-generator controls to adjust their reference power settings.

III. TWO AREA SYSTEM

By the interconnection we can increase power generation capacity and reliability of the system. But for interconnection of any two systems two main conditions it has to be satisfied those are as follows

i) Frequency of Generation by the two systems must be at same value.
ii) Voltage of generation of two systems must at same magnitude.

If any two systems satisfy this two conditions then they are interconnected by the help of tie-line which is used to transfer power between the two areas. In this interconnected power system two parameters we have to control are Frequency of the system and Tie line Power flow. In order to know how these two parameters with respect to load are known by the help of mathematical modeling

IV. MODELLING OF TWO AREA SYSTEM

Let two areas are connected with the help of a tie line then power transfer between these two areas is given by as follows

$P_{tie-1} = (V_1\ V_2\quad X_{12}) \sin (\delta_1 - \delta_2)$ ------- (1)

Where

$\delta_1,\ \delta_2$ ----- power angles of equivalent machines to two areas

For an incremental changes in δ_1 and δ_2 , the incremental tie-line power can be expressed as

$\Delta\ P_{tie-1} = T_{12}\ (\Delta\delta_1 - \Delta\delta_2)$ ------- (2)

Where

$T_{12} = (V_1\ V_2\ /\ P_{r1}\ X_{12}) \cos (\delta_1 - \delta_2)$ 'synchronizing co-efficient'

$= (P_{r1}/P_{r2})\ T_{12}$

$= a_{12} T_{12}$

Since incremental power angles are integrals of incremental frequencies then eq (1) can be written as

$\Delta\ P_{tie-1} = 2\pi T_{12}(\int \Delta f_1 dt - \int \Delta f_2 dt)$ ------- (3)

Where

Δf_1 , Δf_2 ---- incremental frequencies changes in area 1 & 2

Similarly incremental tie line power out of area-2 is

$\Delta\ P_{tie-1} = 2\pi T_{12}(\int \Delta f_2 dt - \int \Delta f_1 dt)$ ------- (4)

We know power balance equation when applied two areas we obtain as for area-1

$\Delta P_{G1} - \Delta P_{D2} = [2\ H_1\ /\ f_1\ s]\ d/dt\ (\Delta f_1) + B_1\ \Delta f_1 + \Delta\ P_{tie}$

Taking Laplace transform on both sides then equation (6) will become

$\Delta F_1(s) = [\Delta P_{G1} - \Delta P_{D2} - \Delta\ P_{tie-1}(s)]\ x\ [K_{ps1}/(1+sT_{ps1})]$ ----- (6)

So we can obtain

$\Delta\ P_{tie-1}(s) = 2\pi T_{12}/s\ (\Delta F_1(s) - \Delta F_2(s))$ ------ (7)

The mathematical modeling for a two area system has shown below in figure where tow single area systems are interconnected by help of a tie line. Here output of speed governor is given as input to turbine where its output is given input to power system, in along with this change in load and tie line connection are given as inputs to power system.

V. FGPI CONTROLLERS

Any Industry demands precise control of its all operations. This can't be possible with human control. So they incorporated Controllers to improve their production and quality of their goods. An Industrial control system consists of an automatic controller, an actuator, a plant or machine (which to be controlled) and a sensor.

The controllers are classified into

a) Proportional controller

b). Integral controller

c) Derivative controller

a)FUZZY LOGIC CONTROL

Fuzzy modeling is the method of describing the characteristics of a system using fuzzy interface rules. Fuzzy controllers are normally built with the use of fuzzy rules. . The aim of the fuzzy control system[4] is to generally replace a skilled human operator with a fuzzy rule-based system. The FLC provides an algorithm, which can be automatic control strategy, based on expert knowledge into an automatic control strategy [5].

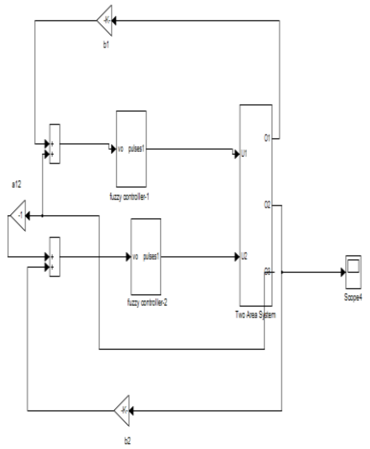
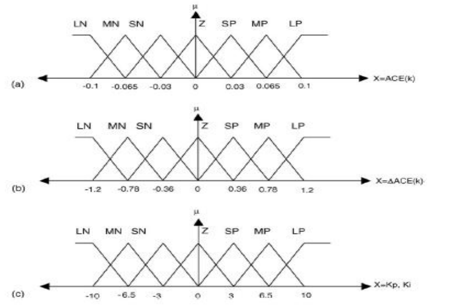


Fig.2 fuzzy logic controller

b) PROPOSED FUZZY LOGIC PI CONTROLLER

To improve its performance automatic controllers were being used. Since power system is highly complex and of higher order, these conventional controllers were not up to the desired performance. Gain –scheduling has been employed in our project to improve its performance. Fuzzy logic controller [6],[7],[8] has used for process of gain scheduling because it is suitable for complex and higher order systems. Among the available controllers PI type is mostly used due to its high performance over the other controllers. So, gain scheduling of PI controller is done by using Fuzzy logic controller [9].



Membership functions for FGPI Controller of (a) ACE, (b) ΔACE, (c) K_P, K_I.

Fig.3 Membership Function For FGPI Controller

Table1:Fuzzylogic rules for FGPI and FL controllers

ACE (k)	ΔACE (k) LN	MN	SN	Z	SP	MP	LP
LN	LP	LP	LP	MP	MP	SP	Z
MN	LP	MP	MP	MP	SP	ZE	SN
SN	LP	MP	SP	SP	Z	SN	MN
Z	MP	MP	SP	Z	SN	MN	MN
SP	MP	SP	Z	SN	SN	MN	LN
MP	SP	Z	SN	MN	MN	MN	LN
LP	Z	SN	MN	MN	LN	LN	LN

LN: large negative; MN: medium negative; SN: small negative; Z: zero; SP: small positive; MP: medium positive; LP: large positive.

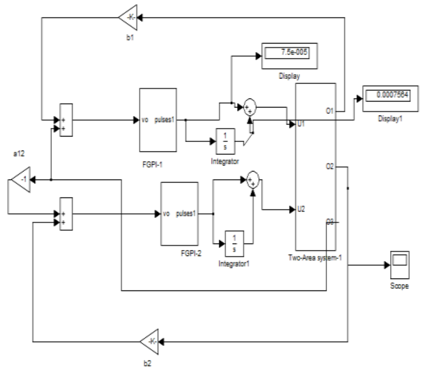


Fig.4simulink model of controller

VI. SIMULINK MODEL OF PROPOSED FGPI CONTROLLER

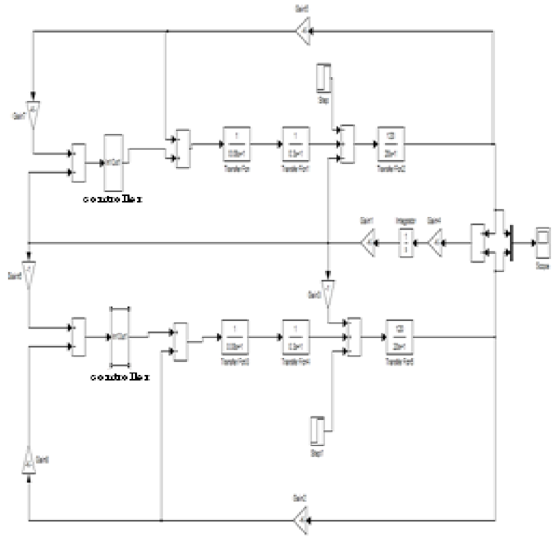


fig.5 simulink model of FGPI controller for two area system

VII. RESULTS

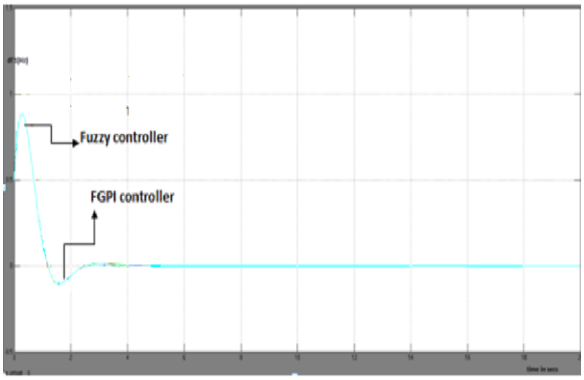


Fig 6 Simulation results of two area interconnected system by FPGI controller and FUZZY controller

Table 2.comparison of FUZZY controller and FGPI controller

Controller name	Peak overshoot	Settling time(msec)
FUZZY controller	1.0	2.5
FGPI controller	1.0	2.2

VIII. CONCLUSION

From above table we observe that peak overshoot and settling time are less for FGPI controller which is applied to two-area interconnection for reducing frequency.

To observe its performance two parameters were considered as settling time and peak overshoot. While its working is compared with other conventional controllers as Fuzzy logic controller. So, our proposed system work satisfactory when compared with Fuzzy logic controller.

REFERENCES

[1] E. Cam and I. Kocaarslan, Load frequency control in two area power systems using fuzzy logic controller, Energy Conversion and Management, vol.46, no.2, pp.233-243, 2005.

[2] K.S. Tang, K.F. Man, G. Chen, S. Kwong, An optimal fuzzy PID controller, IEEE Trans. Ind. Electron. 48 (4) (2001) 757–765.

[3] W. Tan, Uni ed tuning of PID load frequenccontroller for power systems via IMC, IEEE Trans.on Power Systems, vol.25, no.1, pp.341-350, 2010

[4] Ertugrul Cam ,IlhanKocaarslan, A Fuzzy gain scheduling PI controller application for an interconnection electrical power system,vol.73,in 2005,pp.267-274.

[5] L. H. Hassan, H. A. F. Mohamed, M. Moghavvemi and S. S. Yang, Automatic generation control of power system with fuzzy gain scheduling integral and derivative controllers, International Journalof Power Energy and Artificial Intelligence, vol.1, no.1, pp.29-33, 2008.

[6] C.C. Lee, Fuzzy logic in control systems: fuzzy logic controller-part II, IEEE Trans. Syst. Man Cybern. 20 (2) (1990) 419–435.

[7] J . talaq,f. al-basri,adaptive fuzzy gain scheduling for load-frequency control, IEEE trans ,power system.14(1)(1999)145-150.

[8] J.M.Mendel ,fuzzy logic systems for engineering :a tutorial,proc.IEEE 83(3) 345-377.

[9] E. Cam and I. Kocaarslan, A fuzzy gain scheduling PI controller application for an interconnected electrical power system, Electric Power Systems Research, vol.73, no.3, pp.267-274, 2005.

N.VENKATA RAMANA is currently working as a Assistant Professor in EEE Department at Swarnandhra Institute of Engineering & Technology, Seetharampuram, Narsapur. He completed M.Tech in SRI VASAVI Engineering College with the specialization Power Electronics. He completed his under graduation in the stream of Electrical and Electronics Engineering in SWARNADHRA College of Engineering & Technology, Narsapur, and Andhra Pradesh. His areas of interest are Power Electronic drive systems, simulation of power electronic converters.

V. N.SRIHARI RELANGI , pursuing M.Tech in Swarnandhra College Of Engineering & Technology with the specialization Power Electronics. He completed his under graduation in the stream of Electrical and Electronics Engineering in CHALAPATHI Institute of Engineering & Technology, Narsapur, Andhra Pradesh. His areas of interest are Power Electronic drive systems, Modeling and simulation of power electronics.

G.SHINY VIKRAM is currently working as a Assistant Professor in EEE Department at Swarnandhra Institute of Engineering & Technology, Seetharampuram,Narsapur. He received his B.Tech degree in Electrical& Electronics Engineering from Swarnandhra College Of Engineering & Technology and M.Tech degree from Koneru Lakshmiah College Of Engineering.His area of interest includes stability analysis of converters,Switching techniques in power electronics, Power Quality Issues.