Stability Analysis of Controlled Two Area System Using Fgpi Controller

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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 ∆P_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 Δf=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

![Interconnected areas in a power system.](image)

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 ( Δf = 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.

\[ \Delta CE = (P_{tie} - P_{tie,k}) + B_f \Delta f = \Delta P_{tie} + B_f \Delta f \]  

(1)

The first step in the LFC is to form the area control error (ACE) that is defined as where \( P_{tie} \) and \( P_{tie,k} \) 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

\[ \Delta P_{ref,i} = -K_i \int \Delta CE \, dt \]  

(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 be 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

\[ P_{tie} = \frac{(V_1 - V_2)(X_{tie} - X_{tie,k})}{P_{tie}} \sin(\delta_1 - \delta_2) \]

(1)

Where

\[ \delta_1, \delta_2 \ldots \text{ power angles of equivalent machines to two areas} \]

For an incremental changes in \( \delta_1 \) and \( \delta_2 \), the incremental tie-line power can be expressed as

\[ \Delta P_{tie} = T_{12}(\Delta \delta_1 - \Delta \delta_2) \]

(2)

Where

\[ T_{12} = \frac{(V_1 - V_2)(X_{tie} - X_{tie,k})}{P_{tie}} \]

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

\[ \Delta P_{tie} = 2\pi T_{12}(\Delta f_1 - \Delta f_2) \]

(3)

Where

\[ \Delta f_1, \Delta f_2 \ldots \text{ incremental frequencies changes in area 1 & 2} \]

Similarly incremental tie line power out of area-2 is

\[ \Delta P_{tie} = 2\pi T_{12}(\Delta f_2 - \Delta f_1) \]

(4)

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

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

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

\[ \Delta F_1(s) = [\Delta P_{G1} - \Delta P_{tie} - \Delta P_{tie}(s)] \times [K_p/(1+sT_{ps})] \]

(6)

So we can obtain

\[ \Delta P_{tie}(s) = 2\pi T_{12}/s (\Delta F_1(s) - \Delta F_2(s)) \]

(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].

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].
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

<table>
<thead>
<tr>
<th>Controller name</th>
<th>Peak overshoot</th>
<th>Settling time (msec)</th>
</tr>
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<tbody>
<tr>
<td>FUZZY controller</td>
<td>1.0</td>
<td>2.5</td>
</tr>
<tr>
<td>FGPI controller</td>
<td>1.0</td>
<td>2.2</td>
</tr>
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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


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