Load Frequency Control of Two Area Power System Using PID and Fuzzy Logic Controller

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Abstract-- Currently as there has been an increase in the interconnected systems as far as power systems are concerned. Load as well as power flow in tie-line are varying dynamically. So there is a need of robust control of system frequency as well as tie-line power flow system. This robust control could be achieved by the help of fuzzy logic controllers in the place of PID controllers. This is due to the fact that gain constants in the case of conventional controllers remain same throughout, for changes in the load value. But Load can’t be the same throughout, load deviates from time to time. So as to get rid of these disadvantages related to conventional controllers, a lot many schemes have been put forth in literature. With regard to this work, fuzzy logic base controller has been considered for problems pertaining to load frequency control. There queried rules are carried out with respect to the variation in load to diminish the error. In fuzzy logic controller, we take the help of triangular membership function in the formulation of the rule base, because triangular membership function gives easy way to make the rule base compared to other membership functions. Then simulation is done by using Matlab/Simulink software.

Keywords-- PID controller, Fuzzy logic Controller, two area power system, load frequency control, MATLAB SIMULINK.

I. INTRODUCTION

For extensive level power systems which consist of interconnected control regions, load frequency; then it’s paramount to hold into the frequency and entomb territory tie power close to the booked qualities. The input mechanical power is utilized to control the frequency of the generators and the variation in the frequency and tie-line power are detected, which is the extent of the alteration in rotor angle. A decently outlined power framework ought to have the capacity to give the satisfactory levels of power quality by keeping the frequency and voltage size inside middle of as far as possible.

Changes in the power system load influences chiefly the system frequency, while the reactive power is less delicate to changes in frequency and is fundamentally reliant on oscillations of voltage size. So the control of the true and reactive power in the power system is managed independently.

As the loading in a power system is not constant so the controllers for the system must be aimed to provide quality service in the power system. The power flow and frequency in an interconnected system is well regulated by AGC. The main purpose of the AGC is to retain the system frequency constant and almost inert to any disturbances. Generally two things are being controlled in AGC i.e. voltage and frequency. Both have separate control loops and independent of each other.

In this paper, Matlab Simulation is carried out by using PID and Fuzzy logic controllers.

II. TWO AREA POWER SYSTEM

Generally, power systems obligate composite & multi-variable configurations and they have many non minimum and nonlinear phase systems. Power networks are distributed by tie lines into regulator Areas. Generators are expected to maintain synchronism with the tie line and connected Areas. There are basically two types of control mechanism to control frequency in interconnected power systems i.e. first one is primary speed control & second one is secondary speed controller. The first speed control creates the preliminary rough alteration of frequency. For its activities, the variation in load is being tracked by the generators and share among them according to their ratings. The inherent time lags of the system and the turbine itself is the major cause for the slow response of the system. Liable on the turbine kind, the primary loop classically responds in 2–18 s. The later speed control follows the well alteration of frequency by varying the frequency accuracy to zero by an integral control action. The association among the load and speed is accustomed by varying a load set point input. In exercise, the tuning of the load reference mark point is being done by functioning the speed changing motor. This control is significantly sluggish and drives to action only when the job is done by the primary speed control. Regulation of the frequency is done by the speed-governing system. The isochronous governor changes the turbine valve/door to get the frequency once again to the ostensible or booked rate.

III. MODEL OF TWO AREA POWER SYSTEM

Each area is assumed to have only one equivalent generator and is equipped with governor- turbine system. They are the control signals from the controllers we choose. The plant for a power system with a non-reheated turbine consists of three parts:

1. Governor with dynamics: \[ G_g(s) = \frac{1}{1+7s} \]
2. Turbine with dynamics: \[ G_t(s) = \frac{1}{1+7s} \]
3. Load and machine with dynamics: \[ G_p(s) = \frac{1}{1+7s} \]

Figure 1: Block diagram of two area power system

IV. SYSTEM PARAMETERS

The nominal parameters value of Two area power system model is
Table 1: The nominal parameters value of Two area power system

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Nominal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_g$ (Time constant of the generator)</td>
<td>0.08</td>
</tr>
<tr>
<td>$T_t$ (Time constant of the turbine)</td>
<td>0.3</td>
</tr>
<tr>
<td>$R_1$ and $R_2$ (Speed regulation constant)</td>
<td>2.4</td>
</tr>
<tr>
<td>$b_1$ and $b_2$ (Feedback bias coefficient)</td>
<td>0.425</td>
</tr>
<tr>
<td>$k_p$ (Proportional gain constant)</td>
<td>120</td>
</tr>
<tr>
<td>$T_p$ (Power system time constant)</td>
<td>20</td>
</tr>
<tr>
<td>$a_1$ and $a_2$ (Synchronizing power coefficient)</td>
<td>-1</td>
</tr>
</tbody>
</table>

V. PID CONTROLLER

A. Introduction

A Conventional PID controller is most widely used in industry due to ease in design and inexpensive cost. The PID formulas are simple and can be easily adopted to corresponding to different controlled plants but it can’t yield a good control performance if controlled system is highly order and nonlinear. The PID controller is a combination of the PI and PD controllers. The PD control, as in the case of the lead compensator, improves the transient-response characteristics, improves system stability, and increases the system bandwidth, which implies fast rise time.

B. Mathematical expression PID controller

The actuating signal for the PID controller and the transfer function are given in (1) and (2).

\[
e_a = e(t) + K_s \int e(t) dt + K_p \frac{de(t)}{dt} \quad (1)
\]

\[
C(s) = K_p + \frac{K_i}{s} + K_d s = K_p \left( 1 + \frac{1}{T_s} + T_d s \right) \quad (2)
\]

Where: $K_p$=Proportional gain, $K_i$=Integral gain, $T_i$=Reset time, $K_d$=Derivative gain, $T_d$=Rate Time or derivative time

C. Simulink Model and results

Figure 2: General control structure of PID

Figure 3: Simulink model of two area power system with PID controller

The value of $K_p$, $K_i$, and $K_d$ are following

Table 2: Proportional, Integral and Derivative Gain For PID Controller

<table>
<thead>
<tr>
<th>Gain (for area 1)</th>
<th>value</th>
<th>Gain (for area 2)</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K_p$</td>
<td>-1.12557</td>
<td>$K_p$</td>
<td>-1.12578</td>
</tr>
<tr>
<td>$K_i$</td>
<td>-0.958195</td>
<td>$K_i$</td>
<td>-0.948456</td>
</tr>
<tr>
<td>$K_d$</td>
<td>-0.096867</td>
<td>$K_d$</td>
<td>-0.096576</td>
</tr>
</tbody>
</table>

Figure 4: Output frequency response of area-1 of two area power system when disturbance in area-2

Figure 5: Output frequency response of area-2 of two area power system when disturbance in area-2
According to output of PID Controller settling Time, Peak overshoot and Steady state error are given below.

Table 3: Output Result Of PID Controller

<table>
<thead>
<tr>
<th>Settling Time (in sec)</th>
<th>Peak Overshoot (in Hz)</th>
<th>steady state error</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.2</td>
<td>0</td>
</tr>
</tbody>
</table>

VI. FUZZY LOGIC CONTROLLER

A. Introduction

Recently, Fuzzy logic control has found many applications in the past decade. This is so largely because fuzzy logic control has the capability to control nonlinear, uncertain systems even in the case where no mathematical model is available for the controlled system. A fuzzy logic controller can be regarded as a real-time expert system that employs fuzzy logic to manipulate qualitative variables.

B. Design of Fuzzy logic controller

A fuzzy logic model is a logical-mathematical procedure based on an “IF-THEN” rule system that mimics the human way if thinking in computational form. Generally, a fuzzy rule system has four modules.

1. Fuzzification
2. Fuzzy Inference
3. Rule base
4. Defuzzification

C. Simulink Model and results
A set of rules which define the relation between the input and output of fuzzy controller can be found using the available knowledge in the area of designing FLC. These rules are defined using the linguistic variables. The two inputs results 49 rules are given in table 8.

Table 4: Rule base

<table>
<thead>
<tr>
<th>e</th>
<th>LN</th>
<th>MN</th>
<th>SN</th>
<th>Z</th>
<th>SP</th>
<th>MP</th>
<th>LP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN</td>
<td>LP</td>
<td>LP</td>
<td>LP</td>
<td>MP</td>
<td>SP</td>
<td>Z</td>
<td>SP</td>
</tr>
<tr>
<td>MN</td>
<td>LP</td>
<td>MP</td>
<td>MP</td>
<td>MP</td>
<td>Z</td>
<td>SN</td>
<td>SP</td>
</tr>
<tr>
<td>SN</td>
<td>LP</td>
<td>MP</td>
<td>SP</td>
<td>SP</td>
<td>Z</td>
<td>SN</td>
<td>MN</td>
</tr>
<tr>
<td>Z</td>
<td>MP</td>
<td>SP</td>
<td>Z</td>
<td>SN</td>
<td>MN</td>
<td>MN</td>
<td>MN</td>
</tr>
<tr>
<td>SP</td>
<td>MP</td>
<td>SP</td>
<td>Z</td>
<td>SN</td>
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<tr>
<td>MP</td>
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<td>MN</td>
<td>MN</td>
<td>MN</td>
<td>LN</td>
</tr>
<tr>
<td>LP</td>
<td>Z</td>
<td>SN</td>
<td>MN</td>
<td>MN</td>
<td>LN</td>
<td>LN</td>
<td>LN</td>
</tr>
</tbody>
</table>

Figure 12: Rule viewer for 2 inputs and 1 output

Figure 13: Surface viewer for 2 inputs and 1 output

Table 5: Output Result of Fuzzy Logic Controller

<table>
<thead>
<tr>
<th>Setting Time (in sec)</th>
<th>Peak Overshoot (in Hz)</th>
<th>steady state error</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.2</td>
<td>0</td>
</tr>
</tbody>
</table>

CONCLUSIONS & SCOPE OF FUTURE WORK

A. Comparative analysis

The comparison among different methods in terms of various performance specifications such as settling time, overshoot and steady state error the conventional and intelligent methods has been shown in table 10.

Table 10: Performance analysis of different types of controller

<table>
<thead>
<tr>
<th>Controller</th>
<th>Settling Time (in sec)</th>
<th>Overshoot (Hz)</th>
<th>steady state error</th>
</tr>
</thead>
<tbody>
<tr>
<td>PID Controller</td>
<td>5</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Fuzzy Logic Controller</td>
<td>4</td>
<td>0.2</td>
<td>0</td>
</tr>
</tbody>
</table>

CONCLUSION

The conventional controller and fuzzy logic controller have been designed to load frequency control of two area power system. The performance of all the controllers has been evaluated. Performance evaluation scheme of controller has been done using time response analysis. In time response analysis response of the respective controller has been presented and thereby Settling time, peak overshoot and steady state error have been founded.

The Performance of the each controller is shown table 10. According to the result of Fuzzy logic controller, it gives best settling time and minimum overshoot. Finally it is concluded that by using of different PID and FUZZY LOGIC controller, settling time and peak overshoot of the system is reduced and thus stability is improved. As a further study, the proposed method can be applied to multi area power system load frequency control (ALFC) and also optimum values can be obtained by Genetic Algorithm and Neural networks.
References