A Literature Review on Dynamic Performance of Fuzzy Controller on an Interconnected System

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***Abstract* - Power systems are used to convert natural energy into electric power. To optimize the performance of electrical equipment, it is important to ensure the quality of the electric power. It is well known that three-phase alternating current (AC) is generally used to transport the electricity. During the transportation, both the active power balance and the reactive power balance must be maintained between generating and utilizing the AC power. Those two balances correspond to two equilibrium points: frequency and voltage. The control problem of the frequency and voltage can be decoupled. The frequency is highly dependent on the active power while the voltage is highly dependent on the reactive power. Thus the control issue in power systems can be decoupled into two independent problems. One is about the active power and frequency control while the other is about the reactive power and voltage control. The active power and frequency control is referred to as load frequency control (LFC) [1]. The analysis and design of spontaneous genesis control (SGC) system of individual generator eventually controlling large interconnections between different control areas plays a vital role in automation of power system. The purpose of SGC is to maintain system frequency very close to a specified nominal value to maintain generation of individual unit's at the most economical value and to keep the correct value of the line power between different control areas. In this work, a control strategy has been used to remove area control error (ACE) and to maintain the tie-line power flow at their scheduled values during normal period in an unified power system.This paper presents the spontaneous genesis control (SGC) of an unified two area system. The inputs of the proposed Fuzzy controllers are area control error (ACE), and change of frequency (ΔF).**

***Index Terms* - SGC, load frequency control, Area control error, fuzzy controllers**

I. INTRODUCTION

Megawatt frequency control or Spontaneous Genesis Control (SGC) problems are that of sudden small load perturbations which continuously disturb the normal operation of an electric energy system. The analysis and design of Spontaneous Genesis Control (SGC) system of individual generator eventually controlling large interconnections between different control areas plays a vital role in automation of power system. When load in the system increases turbine speed drops before the governor can adjust the input. As the change in the value of speed decreases the error signal becomes smaller and the positions of governor valve get close to the required position, to maintain constant speed. However the constant speed will not be the set point and there will be an offset, to overcome this problem an integrator is added, which will spontaneously adjust the genesis to restore the frequency to its nominal value. This scheme is called spontaneous genesis control (SGC) .The design of Spontaneous Genesis Control (SGC) system plays a vital role in automation of power system [3].

Fuzzification is the operation of transforming a crisp set to a fuzzy set, or a fuzzy set to a fuzzier set. The operation translates crisp input or measured values into linguistic concepts. This, in a way, is similar to what people may do in numerous situations to reach a decision. For example, if one is told that the temperature is going to be 10 °C, one translates this crisp input value into a linguistic concept such as mild, cold, or warm according to one's inclination, then reaches a decision about the need to wear a jacket or not. Physical control systems are typically of two types: open-loop control systems, in which the control action is independent of the physical system output, and closed-loop control systems (also known as feedback control systems), in which the control action depends on the physical system output. Examples of open-loop control systems are a toaster, in which the amount of heat is set by a human, and an spontaneous washing machine, in which the controls for water temperature, spin-cycle time, and so on are preset by the human. In both these cases the control actions are not a function of the output of the toaster or the washing machine [27]. Examples of feedback control are a room temperature thermostat, which senses room temperature and activates a heating or cooling unit when a certain threshold temperature is reached, and an autopilot mechanism, which makes spontaneous course corrections to an aircraft when heading or altitude deviations from certain preset values are sensed by the instruments in the plane's cockpit.

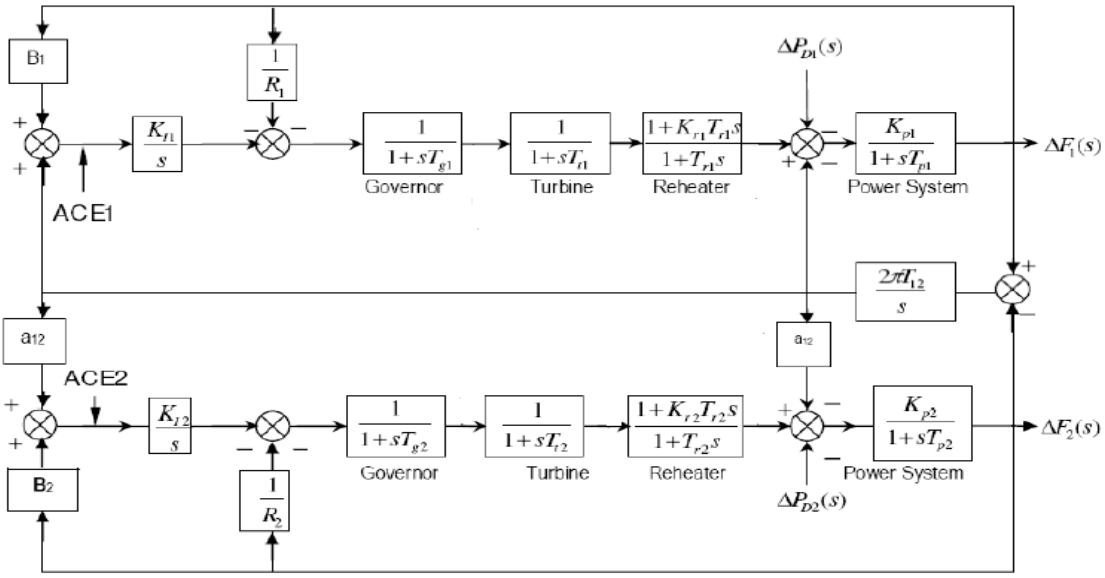

Fig1. Block diagram of two-area spontaneous genesis control

(Blue for Fuzzy controller, Green for PID controller, Pink for PI controller)
Fig3. Frequency deviations in Area-1 with combination of Fuzzy, PI and PID controllers

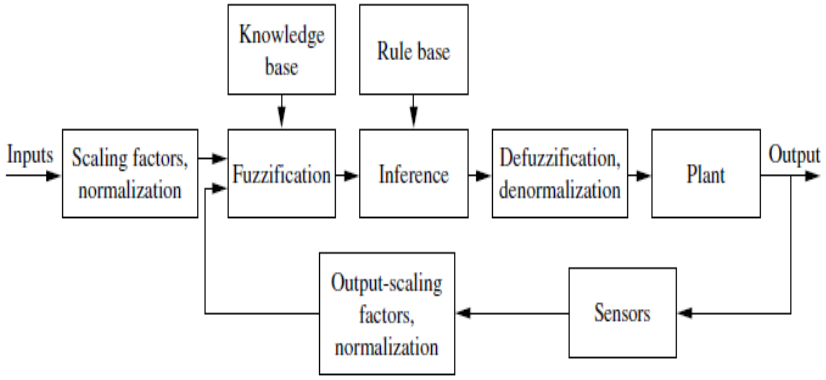

Fig2. A simple fuzzy logic control system block diagram

II. RELATED WORK

Here is the literature survey that is relevant with the work carried out for this paper work.

G.A. Chown et al. [5] described the design, implementation and operational performance of a fuzzy controller as part of the Automatic Generation Control (AGC) system in Eskom's National Control Centre. The fuzzy controller was implemented in the control ACE calculation, which determines the shortfall or surplus generation that has to be corrected.

Bjorn H. Bakken et al. [6] introduced two LFC schemes. One alternative is the general load-frequency control scheme. The LFC handles all system deviations and faults. It will automatically adjust to any manual control actions taken, and can thus be implemented both as a total substitution and as a supplement, to the current Regulating Power Market. However, general LFC based on the Area Control Error might be difficult to implement in a deregulated environment.

Ignacio Egido et al. [7] have purposed a model that has been obtained after analyzing the real response of 14 thermal units. The model consists of a rate limiter, a dead band, a second-order discrete linear transfer function and an offset. This procedure uses real data obtained both from a step response test and an historical behavior of the unit. Results obtained for a coal fired unit and a fuel/gas fired unit has also been presented.

Barjeev Tyagi et al. [8] purposed the design of a decentralized automatic generation control (AGC) scheme for interconnected multiarea power system. A decentralized controller for multiarea AGC, suitable for the restructured competitive electricity market, has been proposed in this paper to meet the Poolco-based as well as bilateral transactions.

J. Nanda et al. [11] described the presence of FLC (Fuzzy Logic Controller) in both areas and small step perturbation in either area or in both areas simultaneously provides better dynamic response than with conventional integral controller. The number of triangular Membership Functions has an impact on dynamic responses and hence needs to be properly selected.

Li Pingkang et al. [12] explained some new concepts for automatic generation control. According to the power system AGC practice demand, the high quality of the electric power demand could be satisfied by using the advanced computer technology, including hardware and software. New algorithm, such as feed forward or predictive with intelligent, will improve the control effort, and the interaction between power plant and power system.

Noureddine Bekhouche et al. [14] presented an algorithm for a decentralized estimation and its application to Automatic Generation Control (AGC) as the Load Frequency Control (FLC) problem in power systems. The variables to be estimated are the frequency deviations and the tie line power deviations for multiarea power systems.

M. G. Rabbani et al. [15] described the application of fuzzy logic control in an Automatic Generation Control (AGC) of an isolated power system that uses a 12-pulse bridge converter associated with Superconducting Magnetic Energy Storage Unit. A systematic approach for designing the fuzzy logic controller (FLC) is proposed in this paper.

J. Nanda et al. [16] explained the automatic generation control (AGC) of a multi-area hydrothermal system. Appropriate generation rate constraints have been considered for the thermal and hydro plants. The hydro area is considered with an electric governor and thermal area is considered with reheat turbine. Optimization of integral controllers and electric governor parameters has been carried out using integral squared error (ISE) criterion.

Nasser Jaleeli et al. [17] described that what automatic generation control (AGC) might be expected to do, and what may not be possible or expedient for it to do. The purposes and objectives of AGC are limited by physical elements involved in the process and, hence, the relevant characteristics of these elements are described.

D.M. Vinod Kumar [18] presented a novel approach of Artificial Intelligence (AI) techniques viz., Fuzzy logic, Artificial Neural Network (ANN) and Hybrid Fuzzy Neural Network (HFNN) for the Automatic Generation Control (AGC). The limitations of the conventional controls viz., Proportional, Integral and Derivative (PID) are slow and lack of efficiency in handling system non-linear ties.

G.L Kusic et al. [19] explained the information about Modern Automatic Generation Control (AGC) sample tie line real power flows, line frequency, and generator power outputs. These analog signals are usually measured two second periodically and combined with desired interchange to obtain the Area Control Error (ACE) .

M S Anower et al. [20] proposed a Fuzzy Frequency Controller (FFC) to improve the dynamic performance of a single-area power system. Further this paper represents the implementation of Fuzzy Frequency Controller for an AGC in single-area power system. The aim of the proposed controller is to restore the frequency to its nominal value in the smallest possible time whenever there is any change in the load demand etc .

III. PROBLEM STATEMENT

The design of Spontaneous Genesis Control (SGC) system plays a vital role in automation of power system.. The performance of Fuzzy Logic Controller (FLC) has been compared with conventional Proportional Integral (PI) controller, Proportional Integral Derivative (PID) controller in the presence of Generation Rate Constraints (GRC). System performance is examined considering step load disturbance in area-1of the two-area interconnected power system.

IV. PROPOSED METHODOLOGY

This paper proposes Fuzzy Logic Controller (FLC) approach for SGC of two-area interconnected reheat thermal power with the consideration of Generation Rate Constraints (GRC). The advantage of proposed controller is that it can handle the system non-linearity and at the same time the proposed approach is faster than conventional controllers gives reduced oscillations and settling time

V. TOOLS USED

All the simulations will be done utilizing the SIMULINK feature in MATLAB. The simulations will be carried out in MATLAB R 2012b in a Windows 8 based PC with 4 GB RAM, 2 GHz processor and 500 GB hard disk.

VI. CONCLUSION

The different conventional controllers and Fuzzy controller have been implemented for the SGC of two-area power system in the presence of GRC. It is clear from the results that the performance of PID controller is better than an Integral controller .In case of the PID controller over shoot and settling time is much smaller as compared to Integral controller .The performance of Fuzzy controller has been compared with that of conventional Integral, Proportional Integral (PI) controller as well as Proportional Integral Derivatives (PID).The Fuzzy controller is faster than conventional controllers and gives reduced oscillations and settling time. This dissertation concludes that the Fuzzy controller is the best out of all the controllers implemented and gives good dynamic performance

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