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Spontaneous Genesis Control Of Unified Power System By Fuzzy Logic Access

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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).**

***Keywords*— 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].

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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.

II. SPONTANEOUS GENESIS CONTROL

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 spontaneousally 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].

A. Real and Reactive Power Control

Power system load flow studies bring out the following properties of power system networks:

1. The changes in real bus power affect mainly the bus voltage phase angles (and therefore real line flows) and have negligible effect on bus voltage magnitudes and reactive line flows.
2. The changes in reactive bus powers affect mainly the bus voltage magnitudes (and reactive line flows) and have negligible effect on bus voltage phase angles and real line flows.
3. The changes in reactive bus powers at a bus have a very strong effect on the voltage magnitude at that bus but have a mild effect on voltage magnitudes at distant buses.

The above system properties lead us to the following two methods of real and reactive power control in power systems.

1) *Load Frequency or Real Power Control*: This is also referred to as Megawatt frequency or power factor control. The aim of this control is to maintain real power balance in the system through control of system frequency..

2) *Reactive Power Control or Spontaneous Voltage Control*: This is also referred to as Mega var voltage or QV control. The aim of this control is to maintain the system voltage between limits by adjusting the excitation of machines.

The above two control channels operate more or less independent of each other. Moreover the power factor loop is rather slow in action due to inertia of mechanical parts whereas the QV loop is very fast. Fig. 3.1 shows the two control channels for maintaining the real and reactive power balance in the system [4]. The loop is not a single one as in case of the AVR. A relatively fast primary loop responds to a frequency signal which, as we have noted, is an indirect measure of megawatt balance. Via the speed governor and the control valves, the steam*(or hydro) flow is regulated with the intent of matching the megawatt output to relatively fast load By thus tending to maintain a megawatt balance, this primary fluctuations [3]. By "fast" we mean changes that take place in one to several seconds.

B. Basic Generator Control Loops

The spontaneous load-frequency control (ALFC) loop regulates the megawatt output and frequency (speed) of the generator. loop performs indirectly a coarse speed or frequency control.A slower secondary loop maintains the fine adjustment of the frequency, and also by "reset" action maintains proper megawatt interchange with other pool members This loop is insensitive to rapid load and frequency changes but focuses instead on drift like changes which take place over periods of minutes

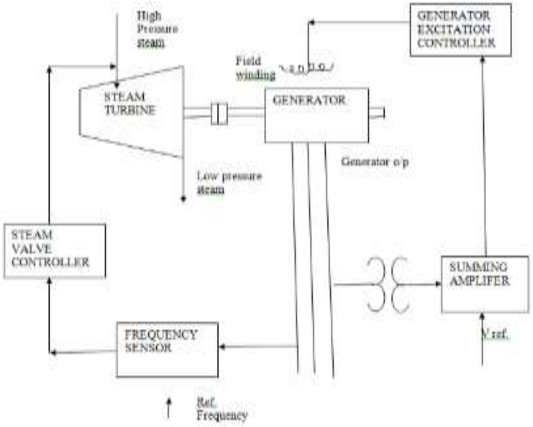

Fig. 1 Load frequency and spontaneous voltage control channels of turbo-alternator

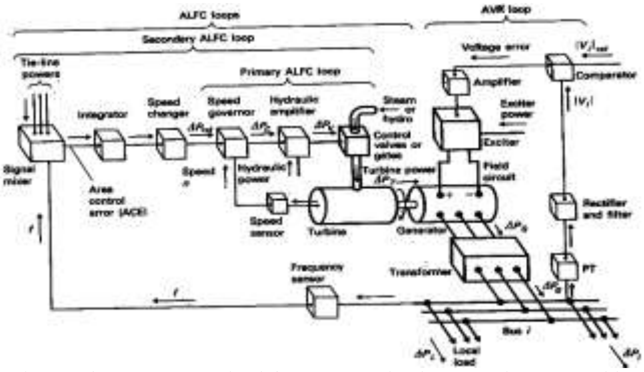

Fig. 2 .The spontaneous load-frequency and voltage regulator control loop

C. Spontaneous Load-Frequency Control of Single-Area Systems

The basic role of ALFC is to maintain desired megawatt output of a generator unit and assist in controlling the frequency of the larger interconnection. The ALFC also helps to keep the net interchange of power between pool members at predetermined-values. Control should be applied in such a fashion that highly differing response characteristics of units of various types (hydro, nuclear, fossil, etc.) are recognized [3].

D. Block Diagram of Single Area Load Frequency Control

The different machines within a single control area form a coherent group. Whenever a change in load occurs, all the machines act together. Thus the response of a single control area can be studied through the, response of a single turbo generator (along with its governor).The response of turbo generator unit depends on the response of the speed governing mechanism, turbine and power system.

E. Turbine Model

Let us now relate the dynamic response of a steam turbine in terms of change in power output to changes in steam valve opening ΔX_E. The dynamic response is largely affected by two factors:

(i) Entered steam between the inlet steam valve and first stage of turbine.

(ii) The storage action in the reheater which causes the output of the low pressure stage to lag behind that of the high pressure stage.

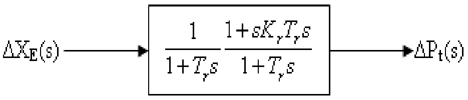

Fig 3. Turbine transfer function model of reheat turbine

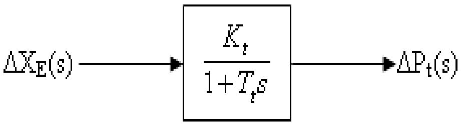

Fig 4. Turbine transfer function model of non-reheat type turbine

F. *Two Area Load Frequency Control*

An extended power system can be divided into small subareas where a group of generators are tightly coupled or close to each other or coupled through small transmission lines, such group of generators respond in Univision for change in load. These control areas are connected by means of tie lines. We shall consider two areas connected by a single tie line as shown in figure 3.6

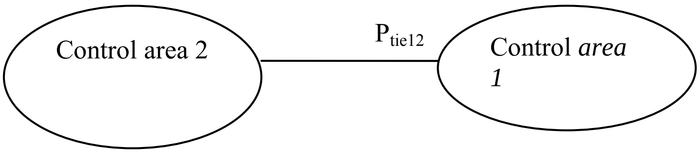

Fig5. Two areas connected by a single tie-line

The power flow on the tie-line from area 1 to area 2 is:

$$\Delta P_{tie1} = \frac{|V_1||V_2|}{X_{12}} \sin(\delta_1^\circ - \delta_2^\circ) \qquad (3.7)$$

Where X_{12} is the tie-line reactance between areas 1 and 2; V_1, V2 at equivalent machine's terminals of the areas 1 and 2 and δ_1, δ_2 = power angles of equivalent machines of the two areas.

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

$$\Delta P_{tie1} = T_{12}(\Delta\delta_1 - \Delta\delta_2)$$

$$\Delta P_{tie1} = 2\pi T_{12}(\int \Delta f_1\, dt - \int \Delta f_2\, dt)$$

Where $T_{12} = \frac{|V_1||V_2|}{P_{r1}X_{12}} \cos(\delta_1^\circ - \delta_2^\circ)$ = synchronizing torque coefficient

Similarly $\Delta P_{tie2} = 2\pi T_{21}(\int \Delta f_2\, dt - \int \Delta f_1\, dt)$

Considering the relationship between area power angle and frequency, (3.8) can be written as:

$$\Delta Ptie_{12} = 2\pi T_{12}(\int \Delta f_1\, dt - \int \Delta f_2\, dt)$$

Where, Δf_1 and Δf_2 are frequency deviations in areas 1 and 2, respectively. Laplace transform of (3.10) means that $\Delta Ptie_{12}(s)$ is obtained.

$$\Delta P_{tie12}(s) = \frac{2\pi}{s} T_{12}(\Delta f_1(s) - \Delta f_2(s))$$

The effect of changing the tie-line power for an area is equivalent to changing the load of that area. Therefore, the ΔP_{tie1} must be added to the mechanical power change (ΔP_m) and area load change (ΔP_L) using an appropriate sign.

The incremental power balance equation for area1 can be written as:

$$\Delta P_{G1} - \Delta P_{L1} = \frac{2H_1}{f_1^\circ} \frac{d}{dt}(\Delta f_1) + B_1\Delta f_1 + \Delta P_{tie1}$$

Taking the Laplace Transform of eqn., we get

$$\Delta F_1(s) = [\Delta P_{G1}(s) - \Delta P_{L1}(s) - \Delta P_{tie1}(s)] \times \frac{K_{ps}}{1+T_{ps}}$$

Where $K_{p1} = 1 / B_1$ $\quad T_{p1} = 2H_1 / B_1 f^\circ$

Compared to equation (3.13) of the isolated control area case, the only change is the appearance of the signal $\Delta P_{tie1}(s)$ as shown in Figure 8.

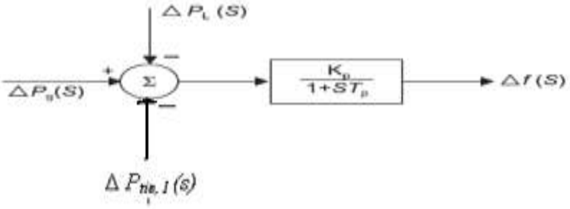

Fig6. Block diagram representation of generator-load model

The next point to consider is the supplementary control loop in the presence of a tie- line. In the case of an isolated area, change in area frequency (Δf) which when used in control loop forced the steady state frequency error to zero. A suitable linear combination of frequency and tie-line power changes for area 1, is known as the area control error (ACE) thus, for control area1,

$$ACE_1 = \Delta P_{tie1} + B_1\Delta f_1$$

Where, the constant B_1 is called area frequency bias.

The above eqn. can be expressed in the Laplace transform as

$$ACE_1(s) = \Delta P_{tie1}(s) + B_1\Delta f_1(s)$$

For the control area 2 ACE_2 is expressed as

$$ACE_2(s) = \Delta P_{tie2}(s) + B_2\Delta f_2(s)$$

Combining the basic block diagrams of the two control areas, with their respective ACEs (obtained through signals representing changes in tie line power and frequency bias) and employing the block diagrams of Figs. 6 to 7, we easily obtain the block diagram of a two area system shown in figure 3.8.

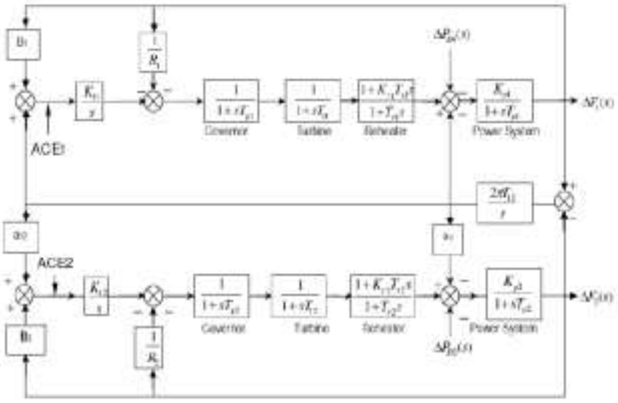

Fig7. Block diagram of two-area spontaneous genesis control

ΔP_{D1}= Incremental load change in area 1
ΔP_{D2} = Incremental load change in area 2
T_t = Turbine time constant
B_1 = Frequency bias constant for area 1
B_2 = Frequency bias constant for area 2
T_P = 2H/ *f* D
K_P = 1/D
D = Load damping constant
K_i = Integral gain
Δf_1 = Change in frequency for area 1
Δf_2 = Change in frequency for area 2

G. *Fuzzy Logic Control*

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. If one fails to fuzzify (for example, due to lack of familiarity with the Celsius temperature scale) then the decision process cannot continue or a possibly erroneous decision would be reached. So, you have been fuzzifying all along (without knowing it) whenever you made correct decisions.

A control system for a physical system is an arrangement of hardware components designed to alter, to regulate, or to command, through a control action, another physical system so that it exhibits certain desired characteristics or behavior. 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.

In order to control any physical variable, we must first measure it. The system for measurement of the controlled signal is called a sensor.The general form of a closed-loop control system is illustrated in Fig.8. The room temperature control and autopilot are examples of regulatory controllers.. The error signal is the difference between the actual response of the plant, as measured by the sensor system, and the desired response, as specified by a reference input. In the following section we describe a typical control system – a closed-loop (feedback) control system.

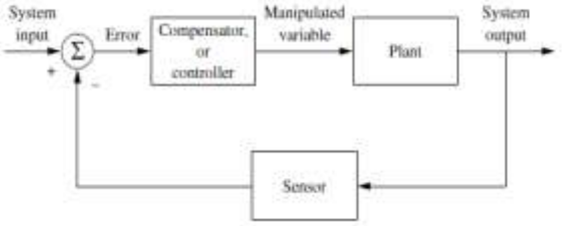

Fig8. A closed loop control system

I. Fuzzy Logic Controller

First-genesis (non-adaptive) simple fuzzy controllers can generally be depicted by a block diagram as shown in Fig. 4.3. The knowledge-base module in Fig. 4.3 contains knowledge about all the input and output fuzzy partitions. The steps in designing a simple fuzzy control system are as follows:

1. Identify the variables (inputs, states, and outputs) of the plant.
2. Partition the universe of discourse or the interval spanned by each variable into a number of fuzzy subsets, assigning each a linguistic label (subsets include all the elements in the universe).
3. Assign or determine a membership function for each fuzzy subset.
4. Assign the fuzzy relationships between the inputs' or states' fuzzy subsets on the one hand and the outputs' fuzzy subsets on the other hand, thus forming the rule-base.
5. Choose appropriate scaling factors for the input and output variables in order to normalize the variables to the [0, 1] or the [−1, 1] interval.
6. Fuzzify the inputs to the controller.
7. Use fuzzy approximate reasoning to infer the output contributed from each rule.
8. Aggregate the fuzzy outputs recommended by each rule.

Apply defuzzification to form a crisp output. The functions of the above modules are described below.

(i) The Fuzzification:

a) Measure the values of input variables
b) Performs a scale mapping that transforms the range of values of input variables into corresponding universe of discourse.
c) Performs the function of Fuzzification that converts input into suitable linguistic values, which may be, viewed labels of fuzzy sets.

(ii) The Knowledge Base:

It consists of data base and linguistic control rule base.

a) The database provides necessary definitions, which are used to define linguistic control rules and fuzzy data, manipulation in an, FLC.

The rule base characterizes the control goals and control policy of the domain experts by means of set of linguistic control rules.

(iii) The Decision Making Logic:

It is the kernel of an FLC; it has the capability of simulating human decision making based on fuzzy concepts and of inferring fuzzy control actions employing fuzzy implication and the rules of inference in fuzzy logic.

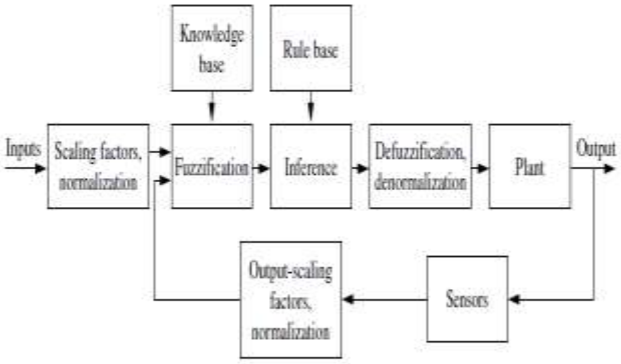

Fig9. A simple fuzzy logic control system block diagram

(iv)The Defuzzification:

(a) A scale mapping which converts the range of values of 1input variables into corresponding universe of discourse.

(b) Defuzzification, which yields a non-fuzzy, control action from an inferred fuzzy control action.

H. Simulation Results and Discussion

Simulation with combination of Fuzzy, PI and PID controllers In conventional controllers I(Integral), PI(Proportional Integral) and PID(Proportional Integral Derivative), PID(Proportional Integral Derivative) controller is better than I and PI controller .Because PID controller's over shoot and settling time is much smaller than Integral and Proportional Integral controller. It is observed that the PID controller gives the better results among all the conventional control techniques but when compared with results of Fuzzy controller, it is observed that the Fuzzy Control gives better results than conventional control techniques The advantage of Fuzzy controller is that it can handle the system non- linearity and at the same time the Fuzzy controller is faster than conventional controllers and gives reduced oscillations and settling time

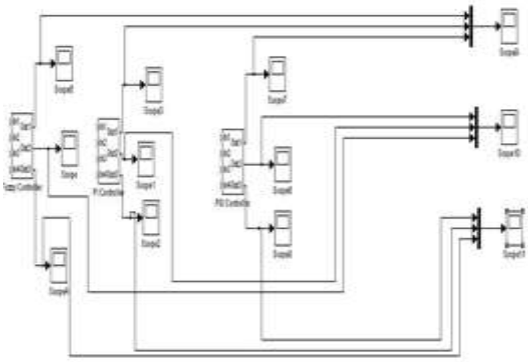

Fig9.Simulink diagram with combination of Fuzzy, PI and PID controllers

(Blue for Fuzzy controller, Green for PID controller, Pink for PI controller) Fig10. Frequency deviations in Area-1 with combination of Fuzzy, PI and PID controllers

(Blue for Fuzzy controller, Green for PID controller, Pink for PI controller) Fig11. Frequency deviations in Area-2 with combination of Fuzzy, PI and PID controllers.

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.

Future Scope

Fuzzy logic and genetic algorithms or ANN can be combined to get good results .The combined use of Fuzzy logic and other intelligent techniques may prove to be better in SGC problems.

REFERENCES

[1]. P. Kundur, ―Power System Stability and Control", New York, McGraw-Hill, 1994.

[2]. Gayadhar Panda, Sidharth Panda and Cemal Ardil, ―Spontaneous Genesis Control of Unified Power System with Genesis Rate Constraints by Hybrid Neuro Fuzzy Access", World Academy of Science, Engineering and Technology, vol.5, no.1,pp. 543-548, December 2009.

[3]. O.I. Elgerd, ―Electric Energy Systems Theory- An Introduction", McGraw-Hill, 1982.

[4]. B.R. Gupta, ―Genesis of Electric Energy", Eurasia publishing house LTD, 2002.

[5]. G.A. Chown and R. C. Hartman, ―Design and Experience with a Fuzzy Logic Controller for Spontaneous Genesis Control (SGC)", IEEE Transactions on Power System, vol.13, no.3, pp. 965-970, August 1998.

[6]. Bjorn H. Bakken and Ove S. Grande, ―Spontaneous Genesis Control in a Deregulated Power System", IEEE Transactions on Power Systems, vol.13, no.4, pp. 1401- 1406, November 1998.

[7]. Ignacio Egido, Fidel Fernandez-Bernal, Luis Rouco, Eloisa Porras, and Angel Saiz Chicharro, ―Modeling of Thermal Generating Units for Spontaneous Genesis Control Purposes", IEEE Transactions on Control

Systems Technology, vol.12, no.1, pp. 205-210, January 2004.

[8]. Barjeev Tyagi and S. C. Srivastava, —A Decentralized Spontaneous Genesis Control Scheme for Competitive Electricity Markets", IEEE Transactions on Power Systems, vol. 21, no.1, pp. 312-320, February 2006.

[9]. Janardan Nanda, Ashish Mangla, and Sanjay Suri, —Some New Findings on Spontaneous Genesis Control of an Unified Hydrothermal System With Conventional Controllers", IEEE Transactions on Energy Conversion, vol.21, no.1, pp. 187-194, March 2006.

[10].George Gross, Fellow, IEEE and Jeong Woo Lee, —Analysis of Load Frequency Control Performance Assessment Criteria", IEEE Transactions on Power Systems, vol. 16, no. 3, pp. 520-525, August 2001.

[11]. A. Mangla and J. Nanda, –Spontaneous Genesis Control of an Unified Hydro Thermal System Using Conventional Integral and Fuzzy Logic Controller", International Conference on Electrical Utility, Deregulation, Re-structuring, and Power Technologies, vol.15, no.4, pp. 372-377, April 2004.

[12]. Li Pingkang Beijing and Ma Yongzhen, –Some New Concepts in Modem Spontaneous Genesis Control Realization" , IEEE Transactions on Power Systems, vol.10, no.3, pp. 1232-1236, December 1998.

[13]. J. Nanda and Manoranjan Parida, –Spontaneous Genesis Control of a Hydro- Thermal System in Deregulated Environment", IEEE Transactions on Energy Conversion, vol.28, no.3, pp. 942-947, July 2001.

[14]. Noureddine Bekhouche and Ali Feliachi, –Decenteralized estimation for the spontaneous genesis control problem in power systems", IEEE Transactions on Power Systems, vol.20, no.5, pp. 632-621, June 1992.

[15]. M. G. Rabbani, M. F. Hossain, M. R. I. Sheikh and M. S. Anower ,—Application of fuzzy controlled SMES unit in Spontaneous Genesis Control", 3rd ICECE 2004, pp. 28-30, December 2004.

[16]. J. Nanda, M. Parida, A. Kalam, –Spontaneous genesis control of a multi-area power system with conventional integral controllers", IEEE Transactions on Power System, vol.16, no.4, pp. 1010-1018, December 2002.

[17]. N. Jaleeli, L. VanSlyck, D. Ewart, L.Fink and A. Hoffmann, –Understanding Spontaneous Genesis Control", IEEE Transactions on Power Systems, vol.7, no.6, pp. 1106-1122, August 1992.

[18]. D.M. Vinod Kumar, –Intelligent controllers for Spontaneous Genesis Control", IEEE Transactions on Power System, vol.8, no.5, pp. 557-574, July 1998.

[19]. G. L. Kusic, J.A. Sutterfield, A. R. Caprez, J. L. Haneline and B.R. Bergman ,–Spontaneous genesis control for hydro systems", IEEE Transactions on Energy Conversion, vol . 3, no. 1, pp. 33-39, March 1988.

[20]. M.S. Anower, M.G. Rabbani, M.F. Hossain, M. R. I. Sheikh and M Rakibul Islam, –Fuzzy frequency controller for an SGC for the improvement of power system dynamics", 4th ICECE 2006, vol.26, no.16, pp. 5-8, December 2006.

[21]. M.F. Hossaiin, T. Takahashi, M.G. Rabbani, M.R.I. Sheikh, M.S. Anower, –Fuzzy Proportional Integral Controller for an SGC in a Single Area Power System" , 4th International Conference on Electrical and Computer Engineering ICECE 2006,vol.29,no.8, pp. 120-123, December 2006.

[22]. H.D. Mathur and H.V. Manjunath, —Frequency stabilization using fuzzy logic based controller for multi-area power system", The South Pacific Journal of Natural Science,vol.23,no.2, pp. 22-30, April 2007.

[23]. A K Swain, Member, —A Simple Fuzzy Controller for Single Area Hydro Power System Considering Genesis Rate Constraints", IE (I) Journal-EL, vol.12, no.4 pp. 12-17, May 2005.