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Evaluation of Artificial Intelligence Technique in Improving Automatic Generation Control

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ABSTRACT: *The Automatic Generation Control (AGC) process performs the task of adjusting system generation to meet the demand for sustainable load control and regulation at the large system frequency changes. In most of the earlier work on the interconnected systems, line of junction bias control strategy has been widely accepted by the public services. In this method, Area Control Error (ACE) is calculated through feedback for each area and control action is taken to regulate ACE to zero. As well, the frequency and power are interchanged retained as large system requirement. The problems of monitoring the frequency of interconnected areas are more important than those isolated areas (simple). Intelligent control techniques provide a strong adherence to the evolution of the conditions and have the ability to make decisions quickly by the treatment of the imprecise information. In this research work, the parameters of the fuzzy controllers are very variable by an appropriate choice of the functions of members and the settings in the basis of rules. The effectiveness of the fuzzy controllers is tested on a double machine operation producing the system with AGC for several points of operation. The two different systems like hydro-thermal and thermal-thermal work based on different frequency conditions. These systems are Comparing for without and with fuzzy system for efficient output.*

***Keyword**-AGC, Energy Management System, fuzzy controller, ACE, Intelligent control techniques*

I. INTRODUCTION

The power System frequency at a constant value is very important for the health of the power generating plants and the utilization of the systems to the customer. The job of automatic frequency control is achieved by the systems of the individual wind turbine generators and Automatic Generation Control (AGC) or Load frequency control (LFC) system of the power system.

The aim of the AGC in a networked power system is to provide the frequency of the individual area to hold and latch - Power line in the vicinity of the planned values by adjusting the MW-outputs of the AGC generators as to accommodate fluctuating load demands. The automatic generation of controller design with improved performance has a significant attention during the past years and many strategies have been developed for the AGC-problem. An interconnected power system consists of areas that are connected with each other by tie lines. In a control area, all generators speed up or slow down to the frequency and the relative strength perpendicular to the planned values in static as well as dynamic conditions. In a networked system, no sudden small fault in the interlinked areas means that the deviation of the frequencies for all areas and also from the tie line power.

Thus, an AGC scheme for an interconnected power system basically incorporates suitable control system, which can bring the area frequencies and tie line powers back to nominal or very close to nominal values effectively after the load perturbations. A disturbance such as the addition of a block of load in a single field of exploitation of the power system to the nominal value of the frequency creates the power of generation and of the request. This offset is first offset by an extraction of the kinetic energy of the system, which causes a decrease in the frequency of the system. As the frequency continues to decrease, the power taken by the old load goes also to decrease. In large power systems, the balance can be achieved mainly by themselves at a time when the new load is offset by the power reduction taken by old Load More. Power corresponding to the kinetic energy extracted from the system. As two area interconnected power system connected through a tie line is shown in Fig. 1. Each domain feeds its area of control and a power line allows current to flow between the areas. A system power supply connected between them can consist of a number of sub-systems or sectors.

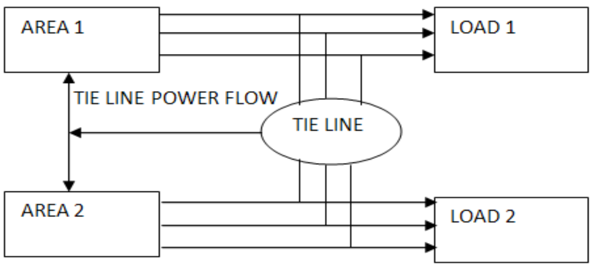


Fig. 1: A two area interconnected power system

A. Major Drawbacks of Conventional Integral Controllers

The drawbacks of conventional integral controllers can be summarized as

- They are slow in the action. This is the lack of effectiveness. So secondary control channel take more time.
- They do not take into account the non-linearity inherent of various components of the power system. Some of the causes of non-linearity are governor dead band effects, use of reheat type of steam turbines in thermal systems, generation rate constraints (GRCs) etc.

Although the load varies continuously during the daily cycle, the operating point will also change accordingly. For best results, the gain of integration should be frequently changed that by the changes in the operating point and it is also to ensure that the value to acquire the best compromise between low overruns in the dynamics of fast transient response and recovery. It is quite difficult to achieve virtually. Thus, a controller is fundamentally a fixed controller, which is optimal to a condition but unsuitable at another stage of operation.

II. AUTOMATIC GENERATION CONTROL

One of the most important elements in the daily operation of a power supply system is the programming and control of production. This function is the main subject of energy control center, and is in large part provided by a control of Automatic Generation Control (AGC) program put in place in the framework of the Energy Management System (EMS).The primary components to consider are the synchronous generators; the prime movers (hydraulic and steam turbines); the speed-governing system, which includes the governor and the load reference actuator (speed changer); the unit controller and the AGC system.

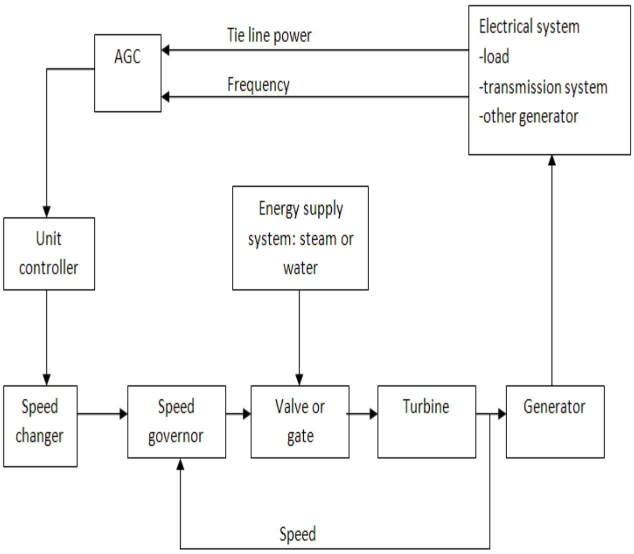


Fig 2. Basic power system control structure

A. Need of Intelligent Control Techniques

The techniques of intelligent control are a great help in the implementation of the AGC for power systems. The power systems of today are more complex and require in the uncertainty and the less structured environment. Consequently, secure, economic and operating a system for the supply requires the improvement and innovative methods of control. Intelligent control techniques provide a strong adherence to the evolution of the conditions and have the ability to make decisions quickly by the treatment of the imprecise information. Some of these techniques are based on the model rule of logic programming; reasoning based on the computational approaches, such as fuzzy sets, artificial neural networks, programming and the evolution of the genetic algorithms. In this research work, the fuzzy logic controller (FLC) technique has been used for AGC of interconnected power systems. This fuzzy logic makes many of the benefits that have to discuss in the result of the theory of the controller.

B. Advantages of fuzzy controllers over conventional integral controllers

An FLC controller has many advantages over conventional integral controller

- It adapts quickly to the evolution of points of operation and calculates the commands of optimal control.
- It can perform effectively even with nonlinearities.
- The system parameters are not required during starting.
- It can operate even if the system of entries are temporarily lost or errors are introduced.
- If telemetry failure occurs, FLC controller continues to function without needing any decision support software.

III. FUZZY LOGIC CONTROL

The fuzzy logic is a form of hand of a logical value; it deals with reasoning that is approximate rather than employment and precise. In contrast with the traditional logic, where the theory of binary sets two-valued logic: true or false, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false.

A. Fuzzy Controller

The control of the fuzzy logic is a control algorithm based on a strategy for the control of language, which is derived from the knowledge of experts in a strategy of automatic control. The control of the fuzzy logic does not need of mathematical calculations difficult as the other system of control. While the others the use of the control system for the mathematical calculation difficult to provide a model of the factory controlled, it uses only simple mathematical calculation to simulate the knowledge of experts. Although it does not need to do difficult mathematical calculations, but it can give a good performance in a control system? As well, it can be one of the best answers available today for a broad class of problems of control difficult.

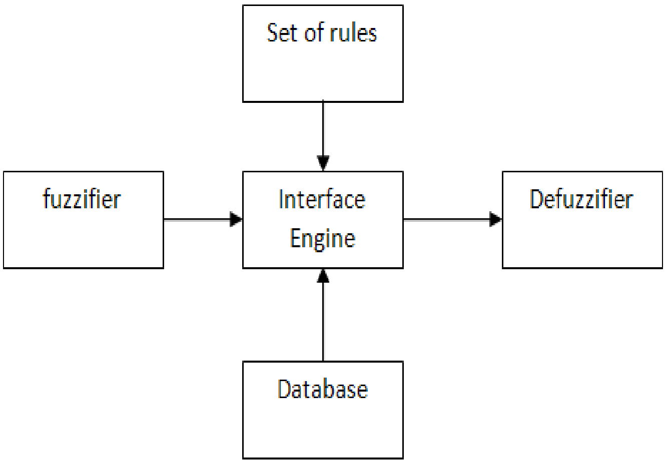


Fig 3: Block diagram of the fuzzy logic controller

Basic configuration of the fuzzy logic is that in the theory of fuzzy sets, the transition between membership and non-membership can be assessed. Consequently, the limits of fuzzy sets can be vague and ambiguous, which is useful in the approximate systems. Fuzzy Logic Controller (FLC) is an attractive choice when precise mathematical formulations are not possible.

There are three principal elements to a fuzzy logic controller.

- Fuzzification module (Fuzzifier)
- Rule base and Inference engine
- Defuzzification module (Defuzzifier)

B. Fuzzy Logic Based Controller

There is a currently a significant and growing interest in the application of intelligence (AI) type models to the problem of modelling the dynamics of complex, nonlinear processes. By far the most popular type of Artificial Intelligence model for these purposes has been the neural network, which attempts to produce ‘intelligent’ behaviour by recreating the hardware involved in the thinking process. Another type of AI model is the fuzzy model, which defines its inputs and outputs as qualitative values (actually fuzzy reference sets) and then defines the strength of the relationships between these input and output reference sets. First of all mathematical model is necessary while making experimentation for control systems but it may not be always possible in practice. Sometimes in spite of creating true model by using of this model makes some complicated problems at the implementation. When confronted with like these problems, knowledge and experience of expert people is utilized. These people develop flexible control mechanism by using the words frequently in our life ,like “suitable”, ”not very suitable”, “high”, “a little high”, “more”, “very more” which are defined special variable. Fuzzy logic control which has experimentation of fuzzy cluster theories and fuzzy logic has been set up like logical relatives. A fuzzy logic system is based on 4 main parts.

- Input units which has been known fuzzifier
- Rule base
- Inference mechanism
- Output units which has been known Defuzzifier

IV. MODELING AND DESIGNING OF GENERATING SYSTEM

The tests were conducted on a networked hydrothermal, provided with heat recovery system type of the turbine and the electrical governor. Off-line simulation model has been developed using MATLAB 7.6.

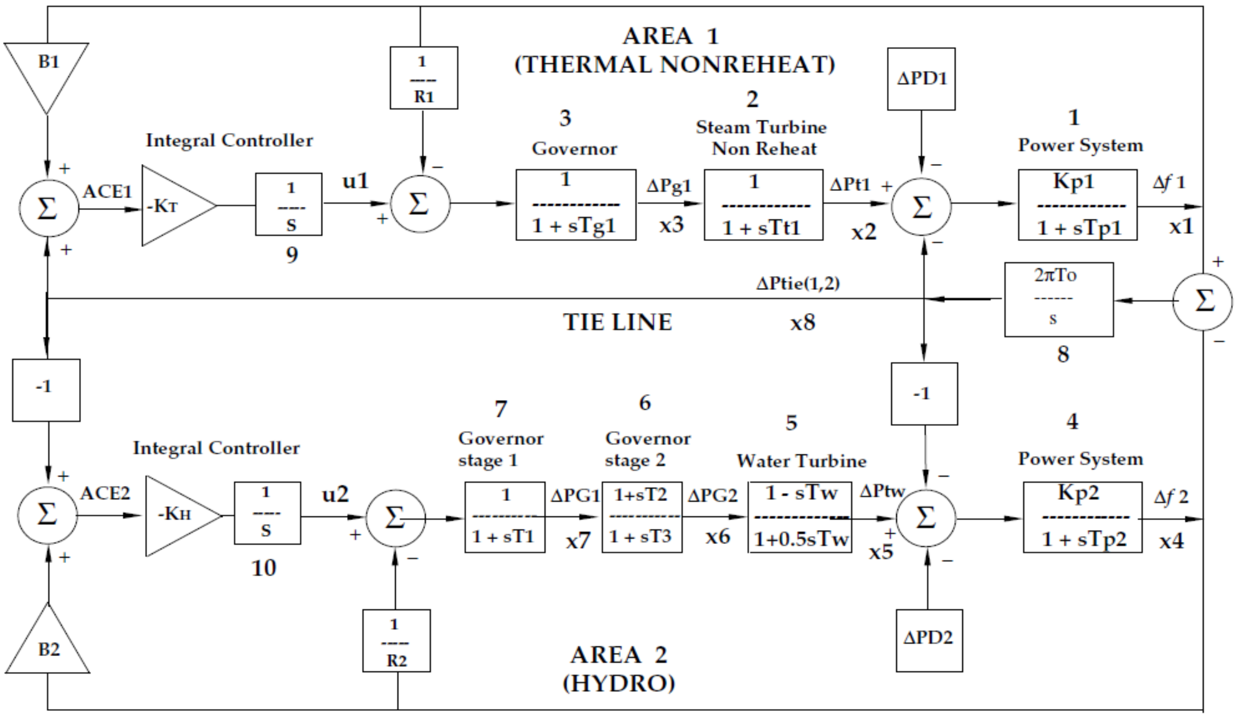


Fig. 4 LTI model of interconnected hydrothermal system with conventional controller

Steam governor was represented by the first order transfer function model while electrical controller was represented by the second order transfer function model. Steam governor controls the steam turbine by controlling the position of the valve, while electrical controls the hydro-input to turbine by controlling the position of gate. The turbine time constant (T_t), reheat time constant (T_r), water time constant (T_w) represents delays due to steam chest and inlet piping, reheated and water flow. Electric governor is supposed to perform proportional, derivative and integrative action.

A. Performance of the Integral Controller

The optimum value of integral controller gain (K_I) is found by using ISE technique, considering 1% step perturbation in either thermal or hydro area. Suffix 1 is used for thermal area and 2 for hydro area. For ISE technique, the objective function used is given in equation.

$$J = \sum_{n=0}^{n=1000} [\Delta f_1^2 + \Delta f_2^2 + \Delta P_{tie}^2] \Delta T \qquad (1)$$

Where, ΔT=small time interval during sample
n=iteration count

ΔP_{tie} = incremental change in tie power

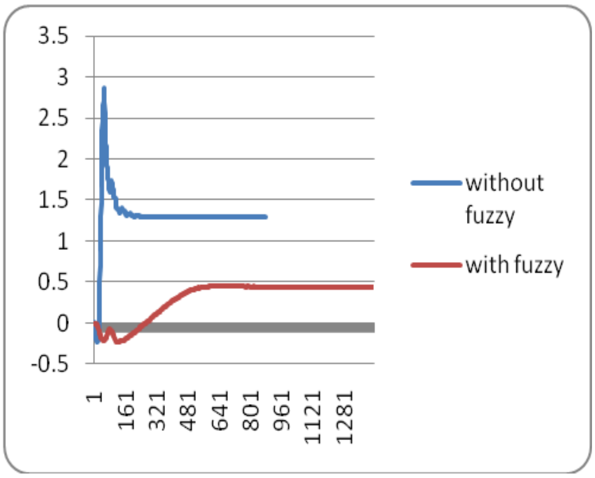
Δf=incremental change in frequency.

A sampling period of 2 sec. is considered. The optimum integral gains of K_{I1}* and K_{I2}* are the values for which, the cost function J is minimum. The optimal integral gains of K_{I1}* and K_{I2}* are found to be 0.12 and 0.09 respectively.

V. SIMULATION AND RESULTS OF AGC TECHNIQUE

A. Simulation Results of hydro thermal system

When we use without fuzzy system then the value of main system is stable after many more time than with fuzzy system. Here hydro thermal system having two systems, first of area 1 shows the value of thermal system and area 2 shows the value of hydro system. When change in frequency of thermal system is about 1% then with fuzzy system have frequency deviation is less. We can easily observe by graph that the change in frequency is very low with fuzzy controller compare to without FLC.



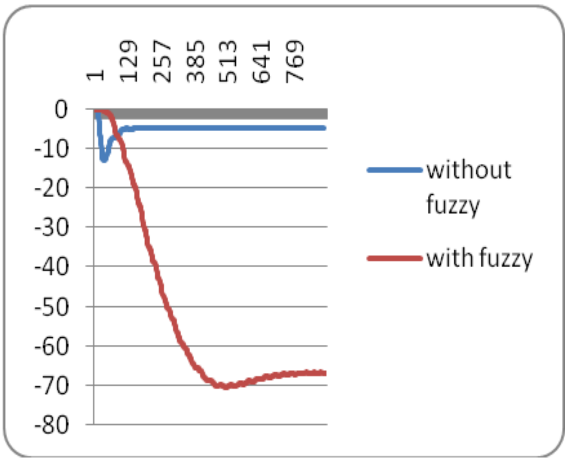
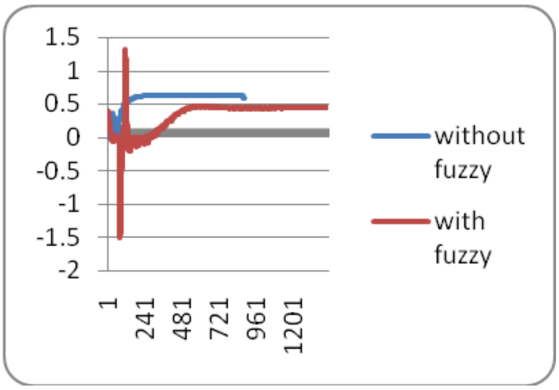


Fig. 5. Change in frequency for 1% load change in area 1 in hydro- thermal systems without and with fuzzy system

Fig. 6 Change in power1 for load change in area 1 in hydro- thermal systems without and with fuzzy system

Power line of area 1(thermal system) shows that total load demand will be completed only with the fuzzy system controlling. Without fuzzy control total power output is very less.



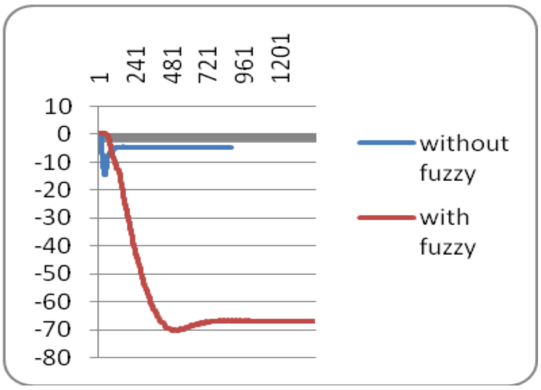


Fig. 7. Change in frequency f2 for load change in area 2 in hydro - thermal systems without and with fuzzy system

Fig. 8. Change in p2 for load change in area 2 without and with fuzzy system of hydro-thermal system

The second system is hydro system that has frequency regulation is depend upon flow of water through pen stock. So initially it is taking more time by gate opening position and system wants stability so system having more disturbances but regulation is small at the end.

Power is also high than without controller because of good controlling through fuzzy. It is about 7 to 8 percent high. Regulation between two systems is more because of different system (hydro and thermal) merge on one load control. Power output by complete system in fuzzy control is more than without fuzzy controlling. At starting system output is same but after some time it increase with load comparison gives us less time to reach on total output changes.

Fuzzy system controlling can be learning easily on MATLAB system. This adds to any generation station with their control system. Both type of system can work in easy way through fuzzy logic controlling. System makes faster and improves all output quantities like power and frequency. These parameters take important part in any power system stability.

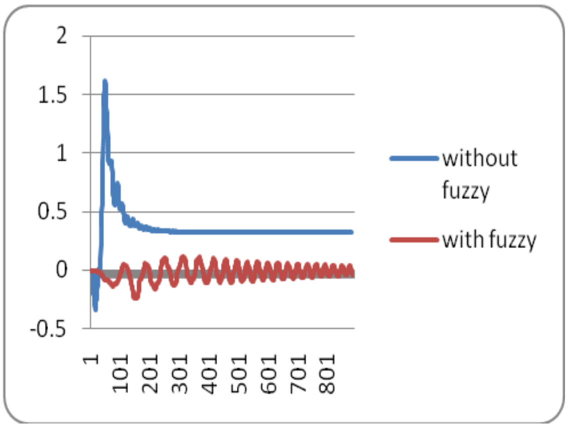


Fig. 9. Feedback change by change in load in hydro- thermal integrator systems without and with fuzzy system

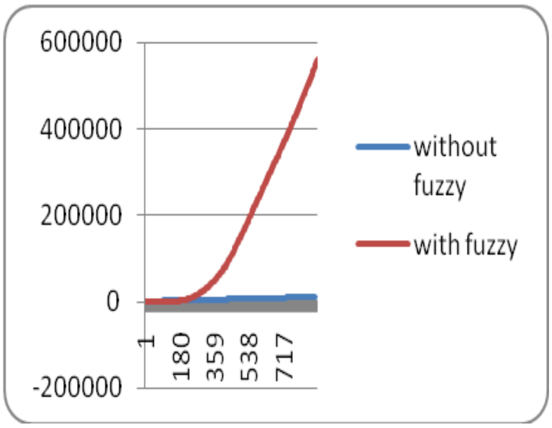


Fig. 10. Power from combined systems with in hydro- thermal systems without and with fuzzy system

VI. CONCLUSION

With conventional integral controller in both the areas, it is permissible to adopt a higher sampling period than a time period, higher the value of T will reduce wear and tear of sampler. The effect of tunable parameters of fuzzy controller present in both the areas of the two area system is better. The system is more stable for same topology. The optimal scaling and membership function width parameter are used in system observation give better dynamic results in case load change occurred in both areas in the system. As the capacity of the area increases, the peak deviation and amplitude of oscillation increases and settling time almost constant or decreases slightly. Also speed regulation parameter 'R' of hydro area needs to be increased to maintain system stability. The parameter of controller is managed by fuzzy system is give more efficient output. It gives less distortion in output frequency and gives more output power in fewer time limits.

APPENDIX :

System Data

KP1 = KP2 = 120 Hz/p.u. MW, TP1 = TP2 = 20 s
R1 = 2.4 Hz/p.u. MW (for thermal), R2=4.8Hz/p.u. MW (for hydro)
B1 = B2 = 0.4249, TG = 0.08 s, TT = 0.3 s, T12 = 0.0866, T1 = 41.6 s, T2 = 0.513 s,
TR = 5 s, TW = 1 s, D1 = D2 = 8.333 × 10-3 p.u. MW/Hz
K_T, $K_{H=}$0.05 pu MW/ Hz Sec, Kr1 & Kr2=5 Thermal Unit

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