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Hybrid Fuzzy Load Frequency Controller for a Two Area Interconnected Power System

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Abstract - This work addresses the special requirements of Automatic Generation Control in Modern interconnected Power system. In order to track the system frequency and handling the power system stability issues many control strategies has been suggested by the researchers .A new Hybrid fuzzy approach is introduced here .Fuzzy Logic controller with Mamdani interface having five member ship functions is tested with the Thermal Thermal and hydro thermal system Further hybrid Fuzzy controller is also tested with the same system and results are compared for the both The system Which is having Hybrid Fuzzy concept and thereby the response of frequency and tie line power can be improved substantially following a load change in any area. Further dynamic responses for small perturbation have been observed, considering HFLC and integral controller and the results of both have been compared.

Keywords - *AGC, ACE, HFLC. Load frequency control, Fuzzy logic control, interconnected power system.*

I. INTRODUCTION

Recent years Demand of the power has been increased from domestic and industrial purposes in all around the world. To decrease this continuous demand many improvements have been done and same is suggested by researchers .The goal is simple and well defined and those are to increase the efficiency and generation level of the whole system

Automatic generation Control (AGC) comes in picture when Parallel operation of the interconnected system is required. For these connected systems Frequency levels and Tie line flows are major concern .The main objective of AGC is to balance system against Load Losses so that desired frequency and power interchange should be maintained for neighboring system .further any mismatch between power generated and Load causes the deviation in system frequency from its normal value .These high deviations of frequency may be turn out to be a major problem related to the system stability and may be a cause for system collapse.

AGC plays an important role to maintain the frequency level and tie line flows within their scheduled values in normal conditions as well as when the system is subjected to load perturbations. Further it can be extended that the goal of AGC to maintain Zero steady state Error in multi area interconnected system

In order to track the system performance and operating conditions many controllers are suggested including Proportional integral controller .however the tuning procedure for these controllers is quite complicated and required accurate values of system parameters, further these controllers do not include Area control error (ACE) and performance is decreased in the presence of any non linearity.

This work Present fuzzy approach towards two area interconnected system network both Thermal Thermal and hydro thermal system are taken. Further A new Controller incorporated with PID Control also is added with fuzzy system [].fuzzy Architecture has 5 member ship function and two variable which is Area control Error and Derivative of the same. The result obtained by using Hybrid FLC's Proposed in this research outperform than those of conventional controller or fuzzy controller.

II. MODERN GENERATION CONTROL AND MODELING

AGC is the name given to the control system which has three main functions:

1. To hold system frequency at or very close to the nominal Value of Frequency (e.g.50 Hz.)

2. To maintain the correct value of interchange power between control
3. To maintain Each unit's generation at the suitable Economic value.

2.1 Supplementary Control

Now Keeping these entire feature in consideration we assume a system which is having a single generation unit supplying load to an isolated power system. A small load change will produce a frequency change with a magnitude that depends on the droop characteristics of the governor and the frequency characteristics of system load. A supplementary control Action is required to reset the frequency to its nominal Value. This can be done by Adding the integral control to the governor further it can be said this control is responsible for maintaining frequency to its nominal value .the goal of this supplementary control action to minimize the error of frequency by adjusting the speed reference set point.

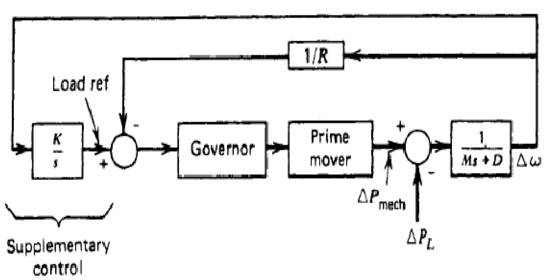

Fig. 1 : Integral Control Action

2.2 Tie Line Control

The power demand has increased over the years and these leads to interconnection of the power system. The objectives of interconnection of the power systems are simple and straight

1. One is to be able to sell or buy power to connected system whose operating costs make such transactions profitable.
2. The system can be protected against loss of generation of any unit which is interconnected; further frequency change is distributed amongst all interconnections.
3. Interconnections present a very interesting control problem with respect to allocation of generation to meet Load.

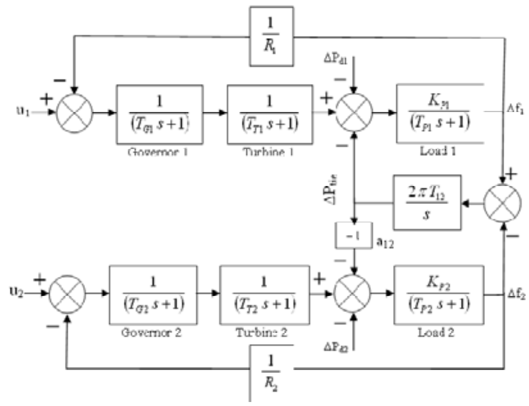

Fig.2 The two Area Interconnected Power System

Such Control system must use two information: the system frequency and the net power flowing in or out over the tie lines. Following control action is suggested in two cases stated below:

1. If frequency decreased and net interchange power leaving the system increased, A load increase has occurred outside the system
2. If frequency decreased and net interchange power leaving the system decreased, a load increase has occurred inside the system.

III. HYBRID FUZZY CONTROLLER FOR MULTI AREA CONTROL

Fuzzy controllers are very simple conceptually. They consist of an input stage, a processing stage, and an output stage. The input stage maps sensor or other inputs, such as switches, thumbwheels, and so on, to the appropriate membership functions and truth values. The processing stage invokes each appropriate rule and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result back into a specific control output value.

The main preference of the fuzzy logic is that is easy to implement control that it has the ability of generalization. The most common shape of membership functions is triangular, although trapezoids and bell curves are also used, but the shape is generally less important than the number of curves and their placement. From three to seven curves are generally appropriate to cover the required range of an input value, or the “universe of discourse” in fuzzy jargon.

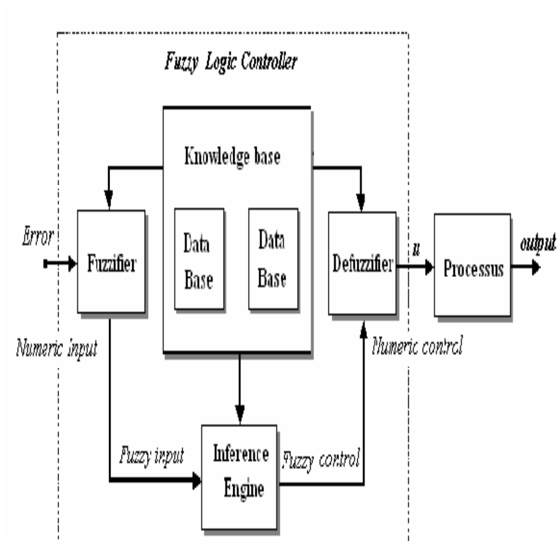

Fig. 3 : Fuzzy Interface

In the fuzzy controller the processing stage is based on a collection of logic rules in the form of IF-THEN statements, where the IF part is called the "antecedent" and the THEN part is called the "consequent". Typical fuzzy control systems have dozens of rules.

Fuzzy Controller has four components:

(1) The fuzzification interface: transforms input crisp values into fuzzy values

(2) The knowledge base: contains knowledge of the application domain and the control goals.

(3) The decision-making logic: performs inference for fuzzy control actions.

(4) The defuzzification interface

Fuzzy Logic control is based on logical system which is much closer to human thinking and natural language than a classical system. Use of this type of controls in Multi area control system is essential and holds good because of these reasons:

1. Inter connected power system posses complexity and multi variable conditions
2. Conventional control Methods may not give satisfactory solutions
3. Robust and reliability make fuzzy controller useful in such type of system.

The model of hybrid fuzzy controller is shown in the fig. In this work two input membership functions Derivative of Δf and Δf for two crisp inputs and one output membership function for output.

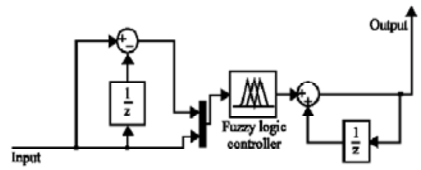

Fig. 4 : Fuzzy Logic Controller used for Simulation

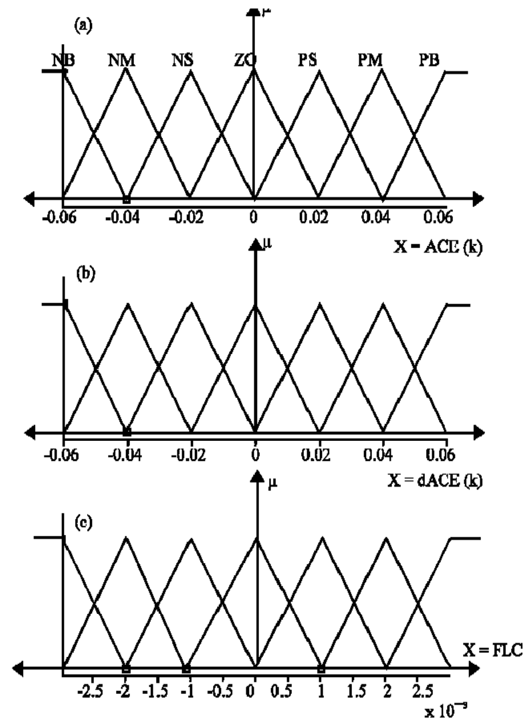

Fig. 5 : Triangular membership function
a: input variable(frequency) b: input variable (Deviation in frequency), c: output variable.

3.1 Architecture of Fuzzy Hybrid Control

A. Scalar Factor tuning

Rules are sometimes defined in the range [0,1] as a result it is necessary to normalize actual variations of the sensor inputs into the interval of [0,1].The input scaling factor AE and ACE are determined by the experts or designers so that the universe of disclosure on the input variables are mapped into unity interval as shown in Fig.6

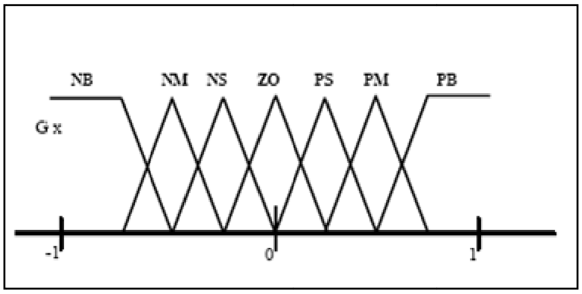

Fig. 6 : Range of Membership functions

Now the Scaling Factors AE and ACE are altered during tuning process and become AE1 and ACE 1 such that

$A_{E1}= K_E * A_E$

$A_{CE1}=K_{CE}*A_{CE}$

Where K_E and K_{CE} are the scaling factors

There for fuzzy architecture can be presented as shown in fig.7

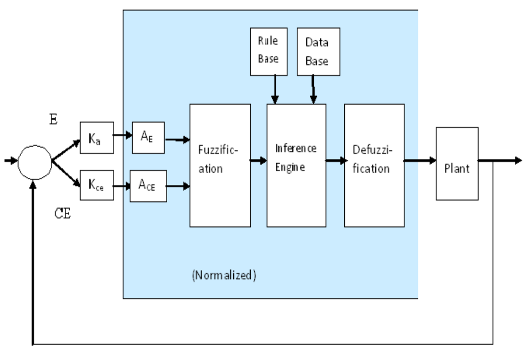

Fig.7 : Fuzzy controller interface

The input scaling factors are nothing but the coefficients between the universe of discourse of the input variables and unity interval for learning controller design most of these variables are unknown and tuning is done according to a learning scheme such as PSO and Genetic Algorithm further these schemes are beneficial to improve the system performance under nonlinearity and derive a better controller.

B. Member ship width tuning

The performance of the fuzzy controller depends upon the designed knowledge base in which membership function and rules are defined the figure shows fuzzy variables with fuzzy subsets .A variable is made up of fuzzy subsets like (NL,ZE,PL) which are formed by their membership functions once the shape and width of and center position of the membership functions are chosen, they cannot be altered in the control process, as we change the width of these membership function A considerable change is observed in output of the systems.

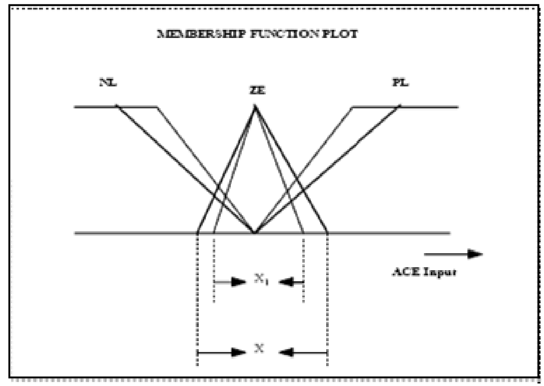

Fig. 8 : Membership function width Variation

IV. SIMULINK MODELS AND RESULTS

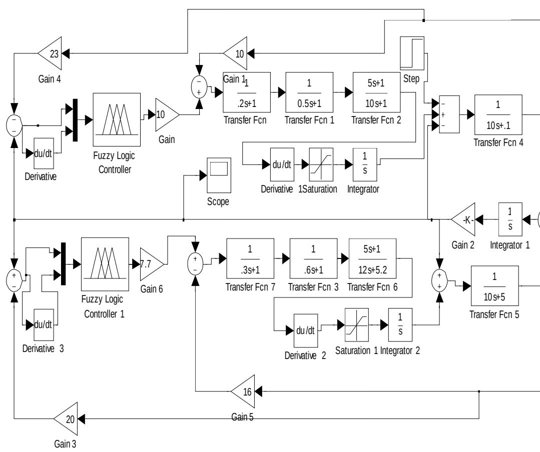

Fig. 9 : Two Area interconnected system Thermal Thermal System

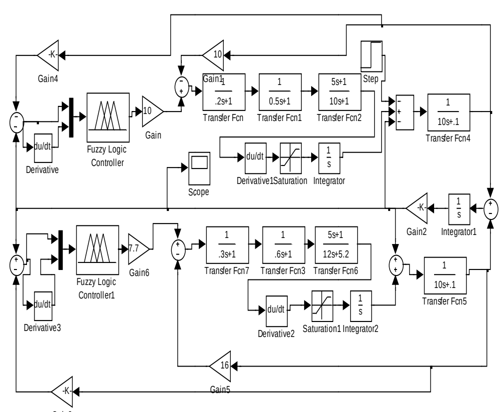

Fig. 10 : Two Area Interconnected System Thermal and Hydro Power system

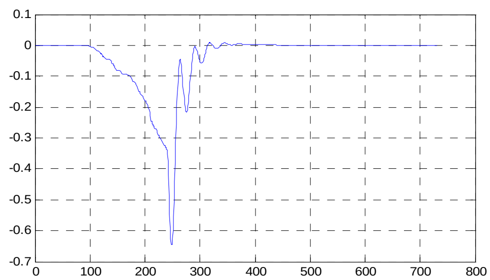

Fig. 11 : Response For Thermal Thermal system

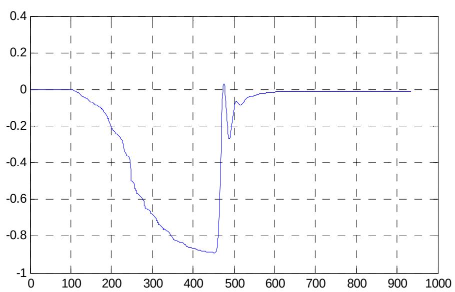

Fig.12 : Response for thermal Hydro system

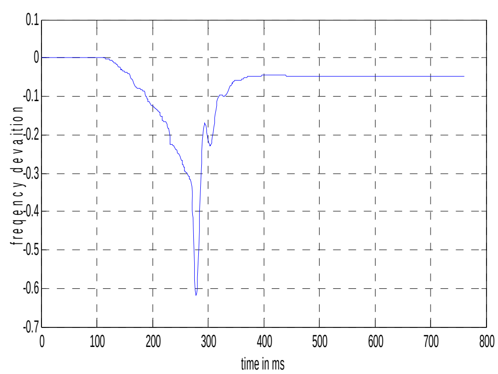

Fig.13: Response for three interconnected systems

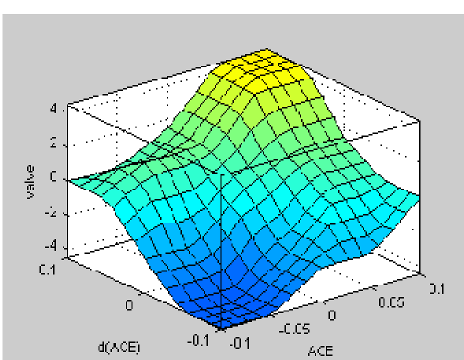

Fig.14 : Fuzzy surface for HFLC

V. CONCLUSION

The main challenges in HFL design for applications with interconnected syetms can be summarized as the need to perform with zero steady-state error for frequency deviations and good performance under Load perturbations. A suitable approach to meet the above requirements is the Hybrid fuzzy logic controller further this HFLC is tested aginst the small step load perturbations of magnitude 0.5 p.u. In case of the uncontrolled studies it is observed that as the load disturbance is increased the static errors are also increasing. For a load disturbances in area 1 with fuzzy controller placed in area 1 the frequency deviation $\Delta f1$ is non – oscillatory where as the variations of Δf exhibit small over shoot before reaching zero steady state value. When fuzzy controllers are placed in both the areas for a step load change in area 1 it is noticed that variations in 1 Δf , 2 Δf are completely non – oscillatory.

Similar conclusions can be drawn for equal step load changes in both the areas having fuzzy controller in area 1. Dead beat responses are obtained with fuzzy controllers placed in both the areas.

When fuzzy controllers are placed in both the areas the deviations are small and the time of state transfer is least with no oscillations.

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