MULTI-AREA POWER SYSTEM USING FUZZY LOGIC BASED LFC AND AVR

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ABSTRACT:

In large scale electric power system, stability plays vital role.The stability problems arises from electric power system interconnected is the low frequency oscillation of the system. The oscillation can be controlled by adjusting exciter and speed-governor control parameters. The Automatic Generation Control (AGC) is driven by the scheduled frequency and the schedule net interchange of the controlled entity. Due to the week coupling relationship between AVR and LFC, the voltage and frequency are regulated separately. This paper focuses on Fuzzy logic based LFC and AVR control scheme to restore the balance between load and generation. The proposed LFC and AVR combined scheme is to be develop for multi-area power systems and simulation is to be carried out by using MATLAB/Simulink environment.

Keywords: Load Frequency Controller (LFC), Automatic Voltage Regulator (AVR), Automatic Generation Controller (AGC), PIDcontroller, and Fuzzy logic controller.

1. INTRODUCTION

In a modern large scale inter connected power system, one of the most significant problem is both active and reactive power demands are never be steady and they will be continually changes with rising and falling trend. The active and reactive power can be maintain constant by adjusting the speed governor parameters in LFC loop and exciter in AVR loop respectively. In inter connected power system manual regulation is not feasible and therefore automatic generation and voltage regulation equipment is installed at the generator. [1][8]

For the efficiency and secure operation of power system, we have a certain objectives. They are

a) Reliability of the system.
b) Security of the system.
c) System should be stable.
d) We must operate the power system in most economical way along with we must provide the power to the consumers with the better quality of the power supply.

2. LOAD FEQUENCY CONTROL

LFC is for regulation of system frequency. It is also called a power factor control loop and influence the active power balances in the power system network. The LFC is achieved by the speed-governor mechanism. The basic principle of the speed-governor mechanism is to adjust itself as per the load variations. The speed of the rotor shaft of the synchronous machine is varied and hence the frequency of the system is also varies. This change in frequency is sensed and compared with a reference and produces a feedback signal. [1][8]

We know $N = 120\, f\,/\,P$

Therefore $N \alpha f$

Where, N = Speed in rpm.

f = Frequency in Hz.

P = Number of poles.

This feedback signal makes the variation of generated power of the generator by adjusting the opening of the steam inlet valve to steam turbine or water gets in the case of hydro turbine. Hence the real power balance between real power generation and real power demand is achieved. In the schematic diagram of LFC loop is consist of two loops. They are Primary control loop and secondary control loop. Primary control loop is also called as a speed governor control loop. It consists of generator, speed governor and turbine. Secondary control loop is consists of primary loop as well as with combination of integral controller.

3. Automatic Voltage Regulator (AVR) loop

AVR is for regulation of system voltage magnitude by automatically. It is also called a Reactive power control loop and influence the reactive power balances in the power system network. The AVR is achieved by the excitation mechanism. The main objective of an excitation system is to control the field current of the generator. Therefore the field current is controlled in order to regulate the voltage of a generator. [1][8]

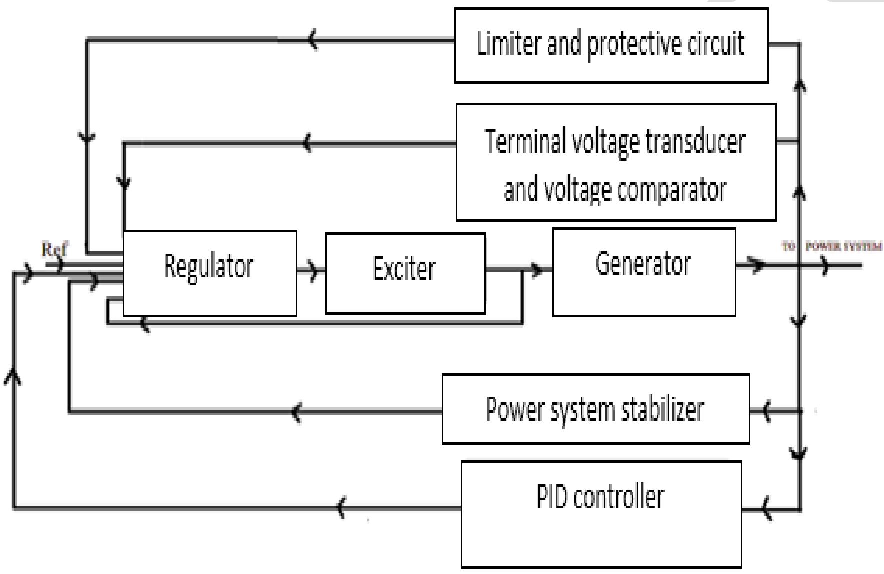

Fig.1 Basic elements of AVR

4. Automatic Generation Control (AGC)

It is the coupling of both LFC and AVR loops and having PID controllers. The real power and frequency is regulated by LFC loop, whereas the reactive power and voltage is regulated by AVR loop. Therefore, the active power, reactive power, frequency and voltage can be regulated in AGC method. In steady state both LFC and AVR loops are non-interactive loop. But during transient state condition both LFC and AVR loops act as interactive. In this state, voltage is also related with active power and hence both loops are interactive in nature. [1][10]

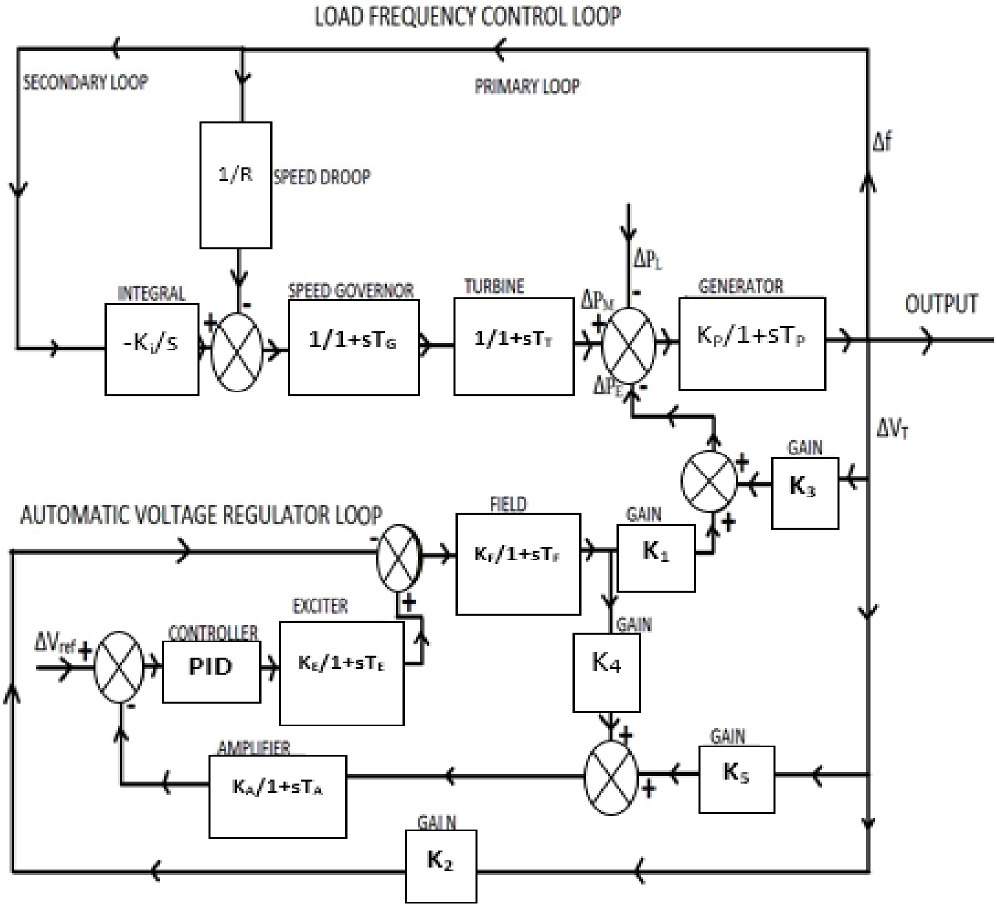

Fig.2 Block Diagram of AGC with LFC AND AVR loop

5. DESCRIPTION OF FUZZY LOGIC

In recent years, the number and variety of applications of fuzzy logic have increased significantly. The applications range from consumer products such as cameras, camcorders, washing machines, and microwave ovens to industrial process control, medical instrumentation, decision-support systems, and portfolio selection.

To understand why use of fuzzy logic has grown, you must first understand what is meant by fuzzy logic.

Fuzzy logic has two different meanings. In a narrow sense, fuzzy logic is a logical system, which is an extension of multivalued logic. However, in a wider sense fuzzy logic (FL) is al- most synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with unsharp boundaries in which membership is a matter of degree. In this perspective, fuzzy logic in its narrow sense is a branch of FL. Even in its more narrow definition, fuzzy log- ic differs both in concept and substance from traditional multivalued logical systems.

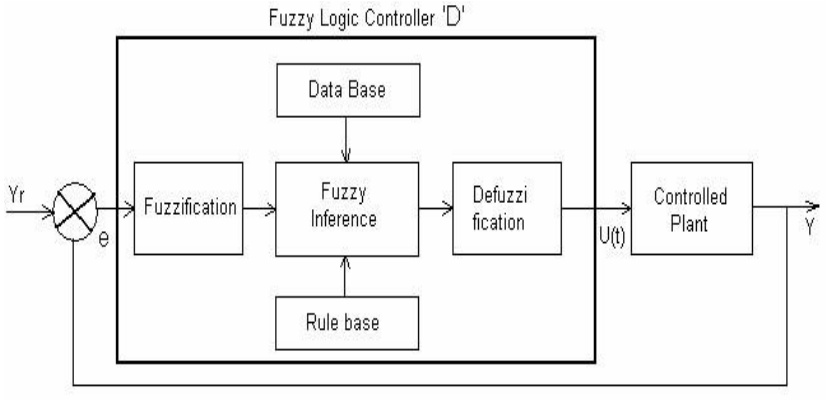

Figure.3 Basic Structure of the Fuzzy Control Systems

The FLC with a rule viewer is selected from the library of the fuzzy toolbox in MATLAB. It is regarded as a nonlinear static function that maps controller inputs into controller outputs. The inputs to the system can change the state of the system, which causes variations in the response characteristics. The task of the controller is then to take corrective action by providing a set of inputs that ensures the desired response. The steps in designing a fuzzy control system are as follows,

1) Identify the input and output variables of the plant.
2) Divide the universe of discourse into a number of fuzzy subsets and assign a linguistic label to each subset.
3) Membership Function is assigned each fuzzy subset.
4) Rule base is formed to relate the input and output variables.
5) Choose appropriate scaling factors for input and output variables in order to normalize the variables to (0, 1) or (-1, 1) interval.
6) Fuzzify the inputs to the controller.
7) Verify the output contributed from each rule.
8) Aggregate the fuzzy outputs recommended by each rule.
9) De-fuzzify the output for converting into crisp values.

The basic structure of FLC consists of three main sections namely,

- Fuzzier
- Rule base and Fuzzy Inference

- Defuzzifier

The fuzzy based control system is designed to control the voltage and frequency of the synchronous generator. The controller uses two input state variables and one output control variable. The difference between the set value and the actual value (error) is termed as the first input variable. The change in error, the difference between the errors in consecutive steps of simulation is assigned as another input variable

ACE						
		PB	**PS**	**ZE**	**NS**	**NB**
d/ dt of A C E	**PB**	PB	PB	PB	PB	PM
	PS	PB	PM	PM	PM	PS
	ZE	PM	PM	PS	PS	PS
	NS	NS	NS	NS	ZE	PS
	NB	ZE	NS	NS	NS	NS

Table-1 **:**(Fuzzy rules)

The rule base consists of a database of the LFC and AVR model.The combinatorial explosion in rules is given by R= l^n .Where, R = Number of rules, l = Number of linguistic labels for each input variable and n = Number of input variables. In the present work, the value of ‘l ‘is 5 and ‘n’ is 2, hence the number of rules R for LFC is 25 as mentioned in Table 1. Similarly, for AVR the value of ‘l’ is 5 and ‘n ‘is 2, hence R is 25. The set of rules which relates the input and output of AVR is tabulated in Table 1.

The mathematical procedure of converting fuzzy values into crisp values is known as defuzzification. Defuzzification plays a great role in a fuzzy logic based control system design, since it converts fuzzy set into a numeric value without losing any information.

A two area system consists of two single area systems , connected through a power line called tie-line, is shown in the Figure 1. Each area feeds its user pool, and the tie line allows electric power to flow between the areas. Information about the local area is found in the tie line power fluctuations. Therefore, the tie-line power is sensed, and the resulting tie-line power is fed back into both areas. It is conveniently assumed that each control area can be represented by and equivalent turbine, generator and governor system.

To maintain net power interchanging in the tie line by the respective scheduled values as per the requirements.

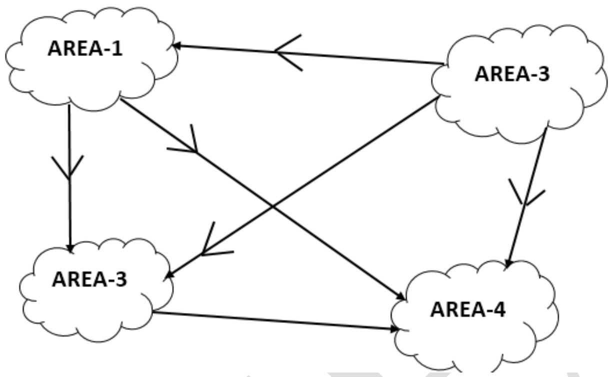

Fig.4 Net Power interchanges between four areas.

Net power interchange of area-1 = $\sum_{i=2}^{N} P_{1i} = P_{12} + P_{13} + P_{14}$

Net power interchange of area-2 = $\sum_{i=1, \neq 2}^{N} P_{2i} = P_{21} + P_{23} + P_{24}$

Net power interchange of area-3 = $\sum_{i=1, \neq 3}^{N} P_{3i} = P_{31} + P_{32} + P_{34}$

Net power interchange of area-4 = $\sum_{i=1, \neq 4}^{N} P_{4i} = P_{41} + P_{42} + P_{43}$

5.2 SIMULATION MODELOF AGC WITH LFC AND AVR

K_I	R	T_G	T_T	K_P	T_P
1	1.7	0.06	0.32	102	20

Table.2. LFC parameters in per unit value

K_1	K_2	K_3	K_4	K_5	K_F	K_A	K_E	T_E	T_A	T_F
1.853	0.1632	0.3457	1.0304	0.0674	0.3794	1	20	0.05	0.05	2.9441

Table.3. AVR parameters in per unit value

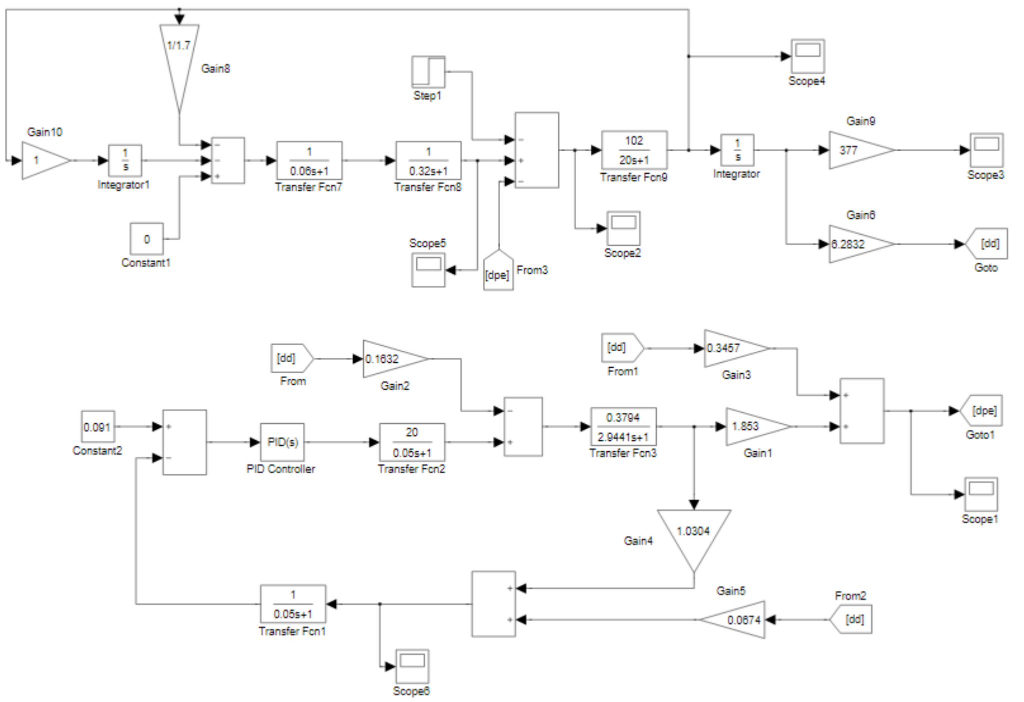

Fig.5 Simulation block diagram for Automatic Generation Control with LFC and AVR loops

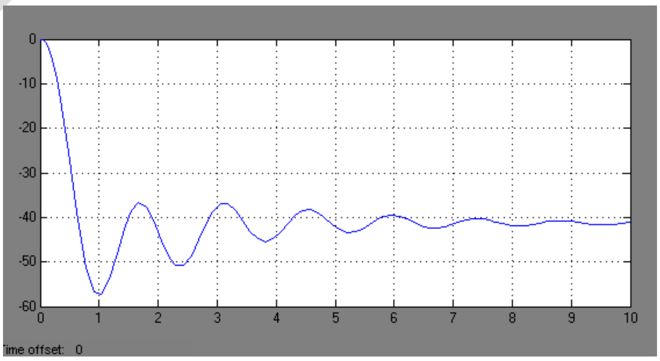

Fig.6 LFC loop response with a simulation time constant T= 10.0.

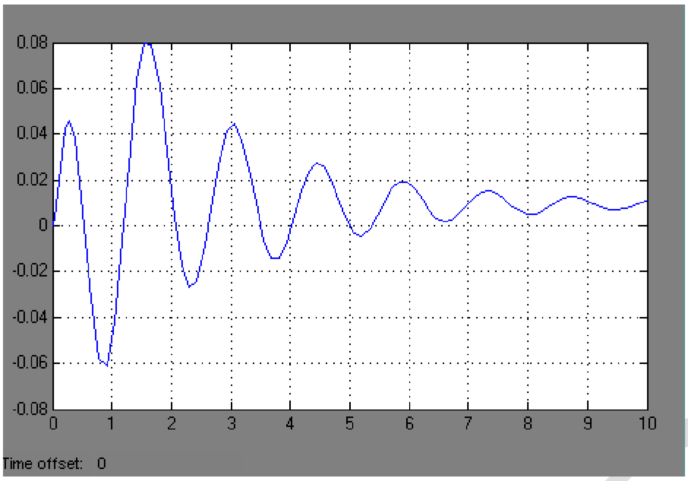

Fig.7 AVR loop response with a simulation time constant T= 10.0.

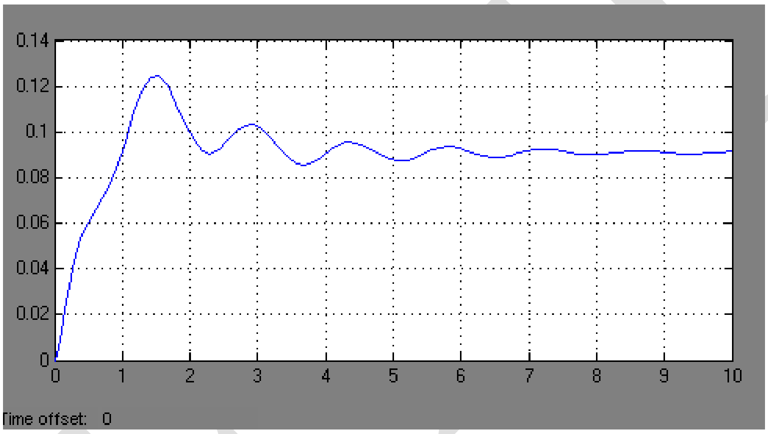

Fig.8 AGC response with simulation time constant T=10.

5.3 Simulink model of two area FUZZY PID

PID Parameters	Area-1	Area-2
K_P	1	1
K_I	1	1
K_D	0	0

Table-4 PID parameters in p.u. Unit value

K_1	K_2	K_3	K_4	K_5	K_F	K_A	K_E	T_E	T_A	T_F
0.425	0.425	1	0.33	1	0.2	0.4	20	0.3	0.5	22

Table-5 FUZZY PID parameters in p.u. values

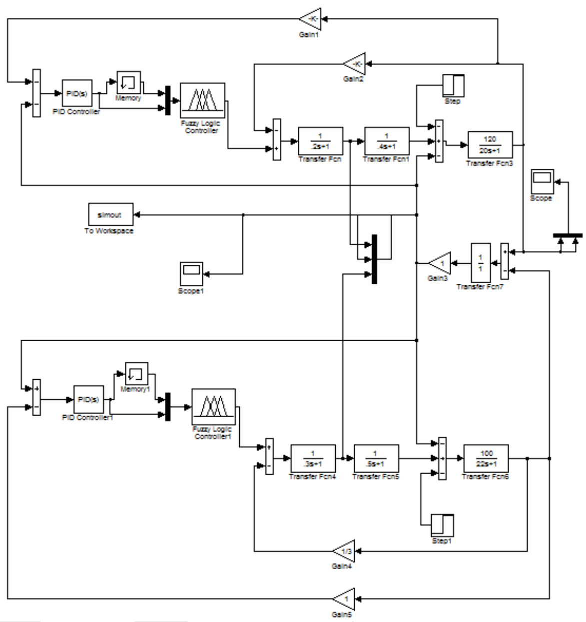

Fig.9Simulink model of two area fuzzy

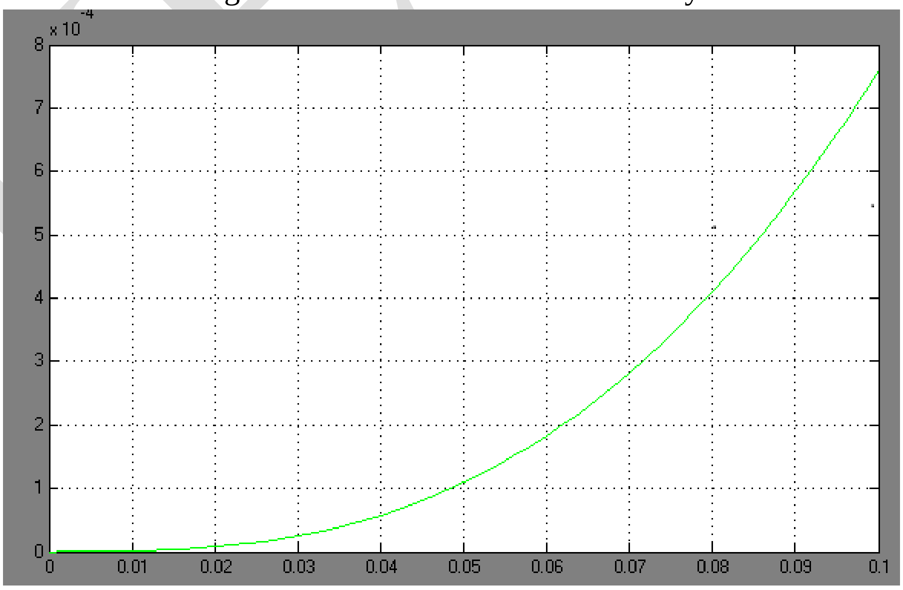

Fig.10response of two area fuzzy PID

CONCLISION

In this paper an approach to the terminal voltage and frequency responses of AVR and LFC loops are inter act with different proportional gains were analysed. The LFC is used to maintain a zero steady state error, while the AVR loop is to maintain the machine output voltage with- in a specified limit. In order to demonstrate the effectiveness of proposedmethod, the control strategy basedon fuzzy logic controller and conventional PID technique is applied to minimize the frequency over shoot and a transient oscillation with in a zero steady state error was obtained. Fuzzy logic controller has been investigated for two area frequency control. And by implementing the fuzzy logic controller with PID shows the intelligent controller is having more improved dynamic response

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