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Automatic Generation Control of Interconnected Reheat Power System with Generation Rate Constraint using Fuzzy Logic Controller

Pooja Devi[1] and Ram Avtar Jaswal[2]

[1,2]Kurukshetra University, Kurukshetra, Haryana, India
[2]Corresponding author; ramavtar.jaswal@gmail.com

Abstract: **In the present work two control areas are analyzed, with reheat thermal power system in each area. For a system Automatic Generation Control (AGC) with the considerations of Generation rate constraints (GRCs) is studied. When Generation Rate Constraint (GRC) is considered, the system dynamic model becomes non-linear and frequency deviation is less when GRC is not considered. The dynamic response with 1% perturbation in system is studied. A control strategy using Fuzzy controller is proposed to active control of system frequency. The advantage of proposed controller is that it can handle the system non-linear ties and proposed scheme is faster than conventional controllers. The response of Fuzzy Controller both in the presence and absence of Generation Rate Constraints (GRCs) is compared. Various results are shown on MATLAB/SIMULNK**.

Keywords: Automatic Generation Control (AGC), AC Tie-line, interconnected power system, generation rate constraints (GRCs).

1. INTRODUCTION

The quality of power means balancing the total system generation against the system load and losses so that the system can remain in steady state. However, both active and reactive power demands are never steady and they continually change with load demand. Steam input to generators, must be regulated to match the active power demand, failing which the speed and thus consequent change in frequency which is highly undesirable. By controlling the excitation of generators, reactive power and thus voltage is controlled. An automatic control system is used to detect the change, as manual regulation is not feasible. This control mechanism is called automatic frequency control (AGC) and detects these changes in power system [1, 2, 3, 4]. The chief objective of the Automatic Generation Control (AGC) is to maintain the desired real power output of a generator and to assist the frequency control of interconnected power system. Automatic Generation Control (AGC) primary loop control uses the governor system to execute the desired control of the generators. Load frequency control with conventional integral controller achieves zero steady state frequency with step input. The basic concepts of speed governors are illustrated by considering an isolated generating unit supplying a local load as shown in fig. 1.

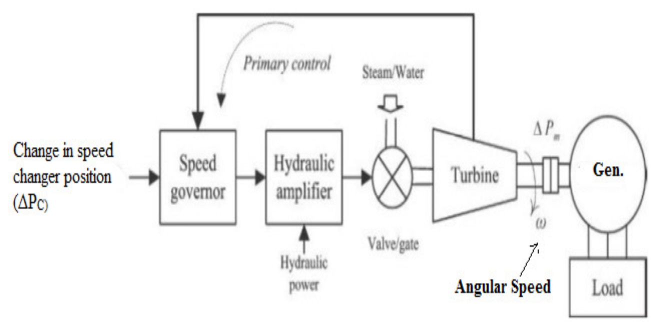

Fig. 1 block diagram of Governor- Turbine with frequency control loop

When two or more power system is interconnected, there are several advantages. One is able to sell and buy power with neighboring systems. Further, even if no power is being transmitted, if one system has power loss of a generating unit, in interconnection all units will experience a frequency change and thus can help in restoring frequency. The following equations represent the net interchange:

$P_{net\ int}$ = total actual net interchange (+ for power leaving the system - for power entering)

$P_{net\ int\ sched}$ = scheduled or desired value of net interchange

$$\Delta P_{net\ int} = P_{net\ int} - P_{net\ int\ sched} \quad (1)$$

We define a control area to be part of an interconnected system within the tie-line power flow is metered. The required change in generation, called the Area Control Error (ACE). ACE represents the shifts in the area generation required to restore frequency and net interchange to their desired values. Thus equations for ACE is

ACE_1 = - $\Delta P_{net\ int1}$ - $B_1 \Delta w$ (2)

ACE_2 = - $\Delta P_{net\ int2}$ - $B_2 \Delta w$ (3)

Where B_1 and $B_2$are called frequency bias factors. Overall control system will try to drive ACE to zero as well as driving each unit's output to its required. It has been discussed that the implementation of such a Fuzzy Logic Controller has greatly improved the operational performance and also robust. Investigations have been carried out on a two area reheat thermal power system considering Generation Rate Constraint (GRC). GRC of 5%/min has been considered.

1.1 Model with Generation Rate Constraint

In power system, power generation can change only at a specified maximum rate and this rate is quite low [5][6] . Most of units have a generation rate around 3%/min and some have between 5 to 10%/min. when we consider the Generation Rate Constraints (GRCs), frequency deviations are more than when we not consider the GRC. Due to effect of presence of Generation Rate Constraints (GRCs) in generation unit, the system model becomes non- linear and linear control techniques cannot apply for controlling purpose. One of the ways of considering the GRCs in plants is to add limiters to the governors for both areas as shown in fig. 2.

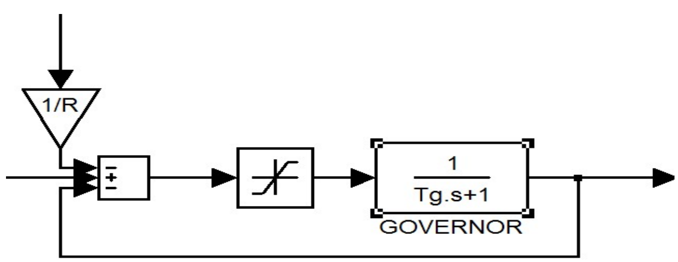

Fig. 2 Governor Model with GRC

The maximum rate of valve opening or closing speed is restricted by the limiters. Here 5%/min is the limit proposed. The GRCs results in larger deviations in ACEs as the rate at which generation can change.

2. DESIGN OF FUZZY LOGIC CONTROLLER (FLC)

There are three principal elements in a Fuzzy Logic Controller as:

- Fuzzifier
- Rule base and inference engine
- Defuzzifier

The first step is to decide which state represents the system dynamic performance must be taken as the input signal to the controller. Fuzzy logic controller (FLC) uses linguistic variables. Therefore, first step is to convert the numerical variables (real number or crisp values) into a linguistic variables and this process is called fuzzification. Inputs to controller are like state error, state error derivative, state error integral etc. are used in FLC. In this work Area Control Error (ACE) and derivative of ACE are chosen to be the input signals of fuzzy [4]. The membership function is a representation of the magnitude of the participation of each member. There are different type of membership function with each type of input and output. In this study, we use the triangular membership function for input and output variable. Five membership functions are used to achieve control using FLC [4]. As the number of linguistic variables increases, both quality improvement in response and computational time are increases. Therefore, a compromise is made to choose the number of variables. For Automatic Generation Control study, five linguistic variables are shown in table 1.

Table 1

d(e) \ e	**NL**	**NS**	**ZZ**	**PS**	**PL**
NL	S	S	M	M	L
NS	S	M	M	L	VL
ZZ	M	M	L	VL	VL
PS	M	L	VL	VL	VVL
PL	L	VL	VL	VVL	VVL

Rules determine the conditional state relationship among fuzzy variables. In this table rules are manipulated as if error is ZZ and change in error is NL then output is M. Similarly, if error is PS, and change in error is also PS then output is VL. With two inputs each having 5 membership function, we have derived 25 rules. The "then" part of the rule is called the rule consequent. The output of FLC is a linguistic variable but according to real world requirements, these have to be transformed to crisp value. Defuzzification is used to transform these variables and this process is opposite that of Fuzzification. Among various methods Mamdani type of defuzzification method is adopted in the present work.

3. RESULTS AND ANALYSIS

The proposed scheme utilizes mamdani-type fuzzy inference system controller. The fuzzy logic is designed by taking error e (t) and rate of change in error de(t) as inputs. The MATLAB/SIMULINK model of two area reheat thermal system with Fuzzy Logic Controller is shown in fig. 3. Fig. 4 and fig. 5 show the dynamic response of a two area reheat thermal system with FLC. Initially the investigations have been carried out by neglecting Generation Rate Constraint (GRC). Fuzzy Logic Controller with 5 number of triangular Membership function have been used to study on system dynamic response. Results obtained by fuzzy controller are compared. Results obtained in the absence of GRC are shown with dash line, the result obtained in the presence of GRC are shown with solid lines. The simulation results prove that the designed controller is robust in its operation and gives a superb damping performance. Proposed controller design is simple and it has the potentiality of implementation in real time environment.

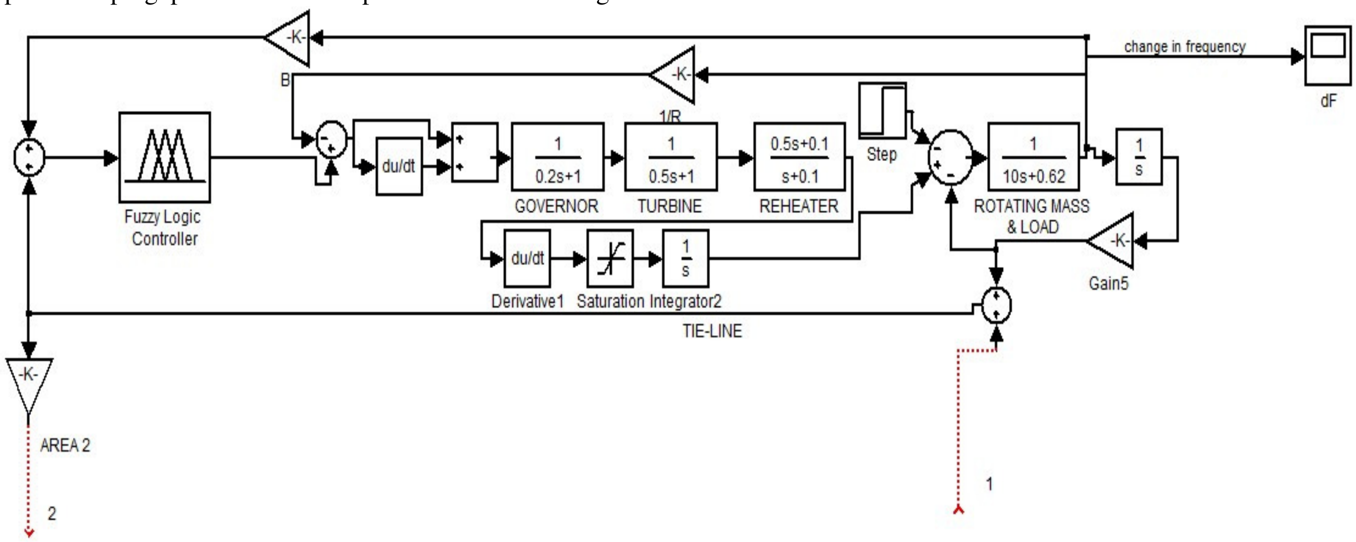

Fig. 3 area 1 of two area thermal power system with GRC

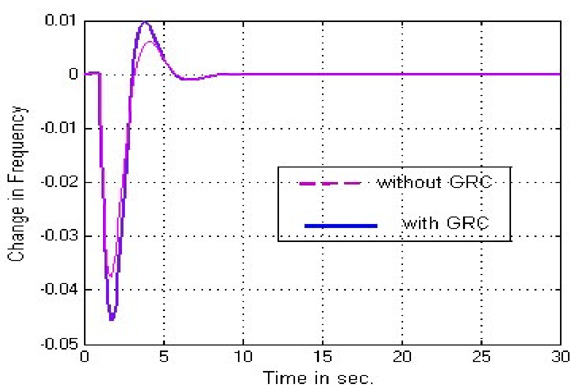

Fig. 4 Frequency response of Area-1

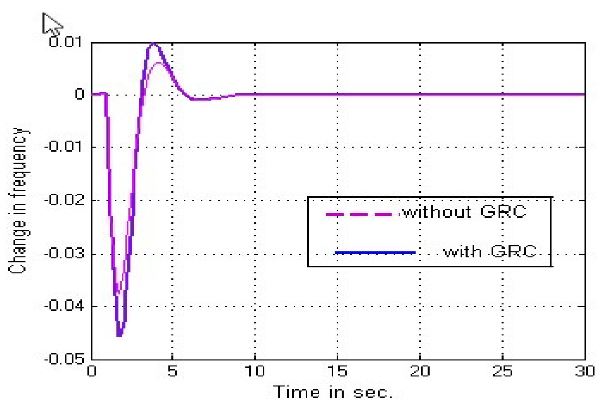

Fig. 5 frequency response of Area-2

4. CONCLUSION

This paper represents the simulation of Automatic Generation Control (AGC) with and without Generation Rate Constraint (GRC) using fuzzy controller. The results are compared. It has been observed that even with GRCs the system remains stable and that the response with and without Generation Rate Constraints are not much differ. Proposed Fuzzy Logic Controller is more accurate and faster and also it gives better results even when Generation Rate Constraint is considered.

REFERENCE: NEED BE CORRECTED AS PER FORMAT OF THE JOURNAL.

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