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# Application of GA based optimal integral gains in fuzzy based active power-frequency control of non-reheat and reheat thermal generating systems

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## Abstract

Optimal integral gains for nominal values of area input parameters and optimal transient responses of area frequency deviations as output with incremental increase of area load have been first computed by Genetic Algorithm (GA) technique for an interconnected, equal non-reheat and reheat type two generating areas. Optimal transient responses have been determined by using Sugeno fuzzy logic technique with GA based optimal gains and then with Matrix-Riccati based optimal gains [IEEE Trans. Power Syst. 14 (1999)] for various imprecise input area parameters. Results of comparative study show much improvement of transient responses in terms of settling times, undershoots, overshoots and df/dt in favor of GA based gains for non-reheat systems. Then, the same gains are applied for reheat systems, resulting in deterioration in performance, though less for GA based gains. So, for reheat systems again GA optimized gains have been computed and yield much improvement in performance. Performance for reheat systems is poorer than that of non-reheat systems owing to higher settling times and overshoots. Gains are also less than those for non-reheat systems. Then, the same analysis has been extended to three-area non-reheat and reheat systems. The same two-area based gains when applied to three-area systems yield poorer performance. Hence, to get better optimal performance GA based optimal gains have also been determined for three-area system, which are also much less compared with similar two-area systems and performance of three-area systems is also poorer than that of two-area systems.

*Keywords:* Optimal integral gains; Non-reheat and reheat thermal generating systems; Genetic algorithm

## 1. Introduction

Active power-frequency control in response to area load changes and abnormal imprecise system operating parameters in a large scale interconnected power systems essentially means area frequency and mutual tie line exchanges between areas are to be satisfactorily maintained very close to specified nominal values. For this, deviations in frequency and tie line exchanges should be minimized as quickly as possible for satisfactory and stable operation of the system with sudden area load changes and abnormal system parameters and conditions.

Over the last few decades, various load frequency control strategies have been developed in order to have better dynamic transient response [1,4].

Fixed integral gain controllers for non-reheat systems have been proposed for nominal operating conditions but they fail to provide best control performance over a wide range of off-nominal operating conditions. So, to achieve optimal performance, various other state feedback and state adaptive optimal controllers [5–7] have been proposed, which require very large, complicated computational burden, memory and time. More recently, fast acting artificial neural networks and fuzzy controllers [3,8] and adaptive fast acting fuzzy gain scheduling for load frequency control [9] have been developed to cater for the uncertainties in the operating power system parameters. In [9], the gains have been computed by solving Matrix-Riccati equation for non-

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reheat two-area systems only. In this paper the same have been computed for both non-reheat/reheat two-area and three-area systems by Genetic Algorithm (GA) which is a very simple, global search technique for optimization [2]. GA based gains have been employed to determine transient response by the Sugeno technique [9] to yield better performance for various off-nominal input operating conditions for both non-reheat/reheat two-area and three-area systems.

## 2. System models for closed loop controlled equal interconnected areas

Block diagram of closed loop controlled three-area system is shown in Fig. 1. Fig. 2 shows the assumed directions of tie-line power flows. Block diagram equations in Laplace domain are shown in Appendix A. Active power-frequency control of these closed loop control systems means minimizing the area control errors ($ACE_i$) to zero so that system frequency and tie-line interchanges are maintained at their scheduled values respectively.

$$ACE_i = \sum_j \Delta P_{tie,i,j} + b_i \cdot \Delta f_i$$

where $ACE_i$ is area control error of ith area, $b_i$ is frequency bias coefficient of ith area, $\Delta f_i$ is frequency error of ith area, $\Delta P_{tie,i,j}$ is tie-line interchange error between the ith and jth area. The integral of $ACE_i$ over a given time interval $\tau$ in Laplace domain is defined by: $(-K_i/s)[\Sigma_j \Delta P_{tie,i,j}(s) + b_i \cdot \Delta f_i(s)]$ (integral gain control)

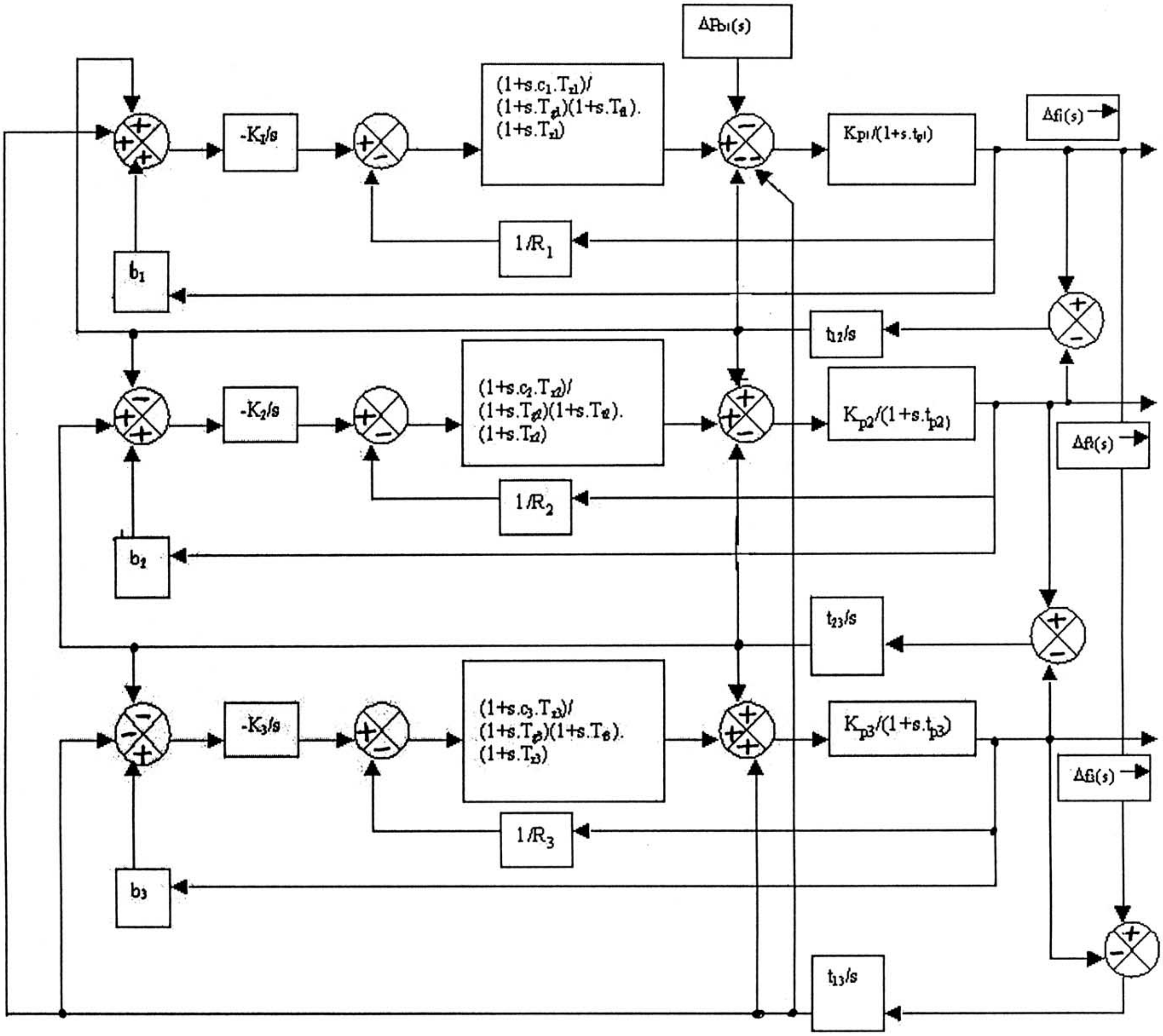

Fig. 1. Closed loop integral controlled ring connected three-area system.