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Modeling and simulation of Load Frequency Controller using Genetic Algorithms Technique

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ABSTRACT

In an interconnected multi-area power system, as a power load demand varies randomly, which results in the variation of frequency, thus leading to load frequency control problem (LFC). The main goals of Load Frequency Control (LFC) are, to hold the frequency and the desired power output in the interconnected power system at the scheduled values and to control the change in the tie-line power flow between control areas. This research involves the load frequency control is done by PI and PID controller, which is a conventional controller. In order to overcome drawbacks a new Genetic Algorithm based controller is presented to quench the deviations in the frequency and the tie line power due to different load disturbances. The proposed controller guarantees stability of the overall closed-loop system. Simulation results for a real three-area power system prove the effectiveness of the proposed LFC and show its superiority over a classical PID controller and a PI controller.

Keywords— *Load Frequency Control (LFC);Integral controller; PID controller; Genetic Algorithm (GA)*

1. INTRODUCTION

When there is change in load occur over a power system, it causes to fluctuate the frequency as well as net tie-line power flow from its optimal operating value. For maintaining power system stability, it is important to consider the way of implementation of the control services that govern the system frequency. Frequency stability not only emphasis on efficiency but also improves reliability and economics of the power system. As the size of the power system increases, it leads to increase in the complexity of the system that requires precise control technique and mechanism of the power system to have healthier and reliable power supply. Therefore, Load frequency Control (LFC) of interconnected power system has the following two main aspects: maintenance of stable frequency and second is to regulate tie-line flow deviation between the interconnected power system at scheduled values [4] [5]. The above mentioned objectives are going to cover in this paper by using PI and PID controllers. The interconnected power system is typically divided into control areas, with each consisting of one or more power utility companies. Sufficient supply for generation of each connected area to meet the load demand of its customers. This research is also focus on Genetic Algorithm Technique (GA), which adds a pole at origin resulting in system type so reducing the steady state error.

2. MATHAMETICAL MODELLING

A. General Description

Load frequency control has a control feature in the speed governing linkage mechanism. In present work, use speed governing linkage mechanism. The error signal i.e. Δf and ΔPtie are amplified, mixed and transformed to real power command signal ΔP_V which is sent to the prime mover to call for an increase in the torque. The prime mover shall bring about a change in the generator output by an amount ΔPG which will change the values of Δf and ΔPtie within the specified tolerance. The first step to the analysis of the control system is the mathematical modelling of the system's various components and control system techniques. In present work, model of following types of power system have be consider for LFC study,

1. Reheat thermal plant
2. Hydro plant
3. Reheat thermal plant

B. Single Area System

(a) Speed Governor

The output commend of speed governor is ΔPg which corresponds to movement ΔXC. The speed governor has two inputs:

1. Change in the reference power setting, ΔPref
2. Change in the speed of the generator, Δf, as measured by ΔX_B.

$$\Delta P_g(s) = \Delta P_{ref}(s) - \frac{1}{R}\Delta f(s) \qquad (3.2)$$

The block diagram corresponding to above equation as shown in fig 1.

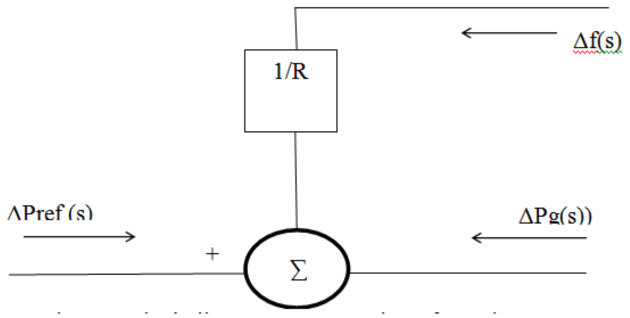

Fig.1 Block diagram representation of speed governor

(b) Reheat thermal unit

$$G_S(s) = \frac{\Delta Pv\ (s)}{\Delta Pg\ (s)} = \frac{1}{Tg*s+1}$$

The block diagram of the speed governor together with the hydraulic valve actuator is shown in Fig 2.

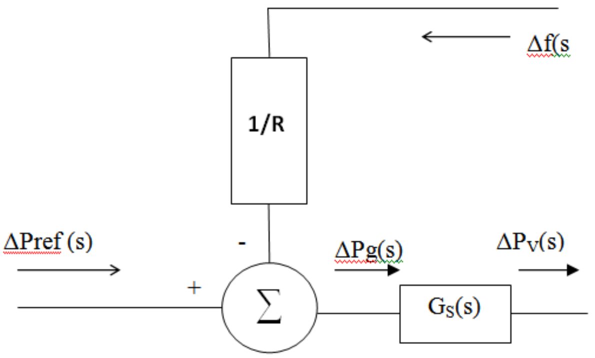

Fig.2 Block diagram representation of thermal governor

Where,

ΔPv = the output of the hydraulic actuator

ΔPg= the output of speed governor

$Tg = \frac{1}{Kg}$ = steam governor time constant

(c) Hydro plant unit

$$\frac{\Delta P_m\ (S)}{\Delta G(S)} = \frac{\Delta P_m\ (S)}{\Delta G(S)} = \frac{1-T_W(S)}{1+0.5*T_W(S)}$$

Where,

T_W = Water starting time

G = Gate position

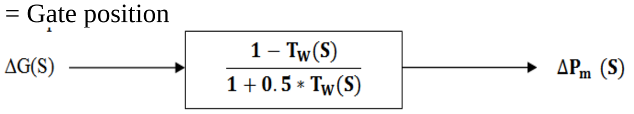

Fig.3 Block diagram representation of Hydro-turbine

(d) Generator and load

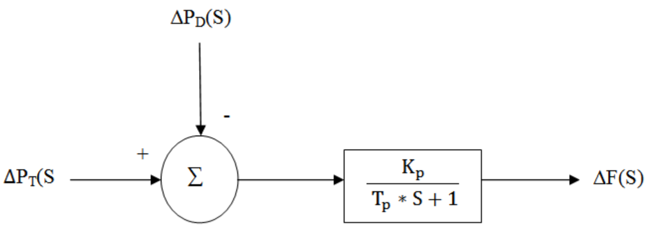

Fig. 4 Block diagram representation of Generator-Load model

Where,

$$Gp\ (s) = \frac{1}{\frac{2H}{f^0}S+D} = \frac{\frac{1}{D}}{\frac{2H}{f^0 D}S+1} = \frac{K_p}{T_p*S+1}$$

$$K_p = \frac{1}{D}$$

$$T_p = \frac{2H}{f^0 D}$$

(e) Block Diagram of Single-Area

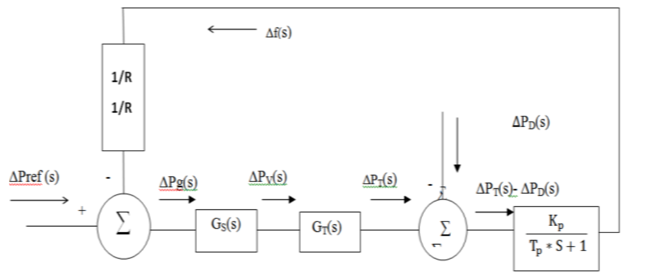

Fig.5 Complete Block diagram representation of Single Area

3. AREA CONTROL ERROR

For the control area-1

$$ACE1 = \Delta P_{tie1} + B_1 \Delta f_1$$

Where the constant B, is called area frequency bias.

Similarly, for the control area-2, ACE2 is expressed as,

$$ACE_2(s) = \Delta Ptie_2(s) + B_2 \Delta f_2(s)$$

And for the control area-3

$$ACE_3(s) = \Delta Ptie_3(s) + B_3 \Delta f_2(s)$$

$$\frac{\Delta Ptie,1}{\Delta Ptie,2} = - \frac{T_{12}}{T_{21}} = - \frac{1}{a_{12}} = \text{constant}$$

4. TWO AREA SYSTEM

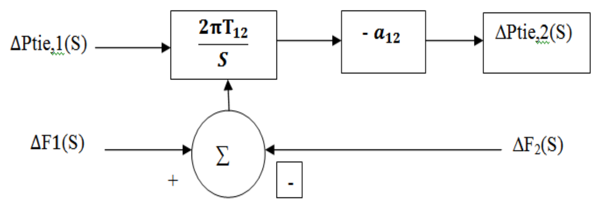

Fig.6 Complete Block diagram representation of Two Area

5. LFC IN MULTI AREA SYSTEM

In an interconnected (multi area) system, there will be one ALFC loop for each control area.

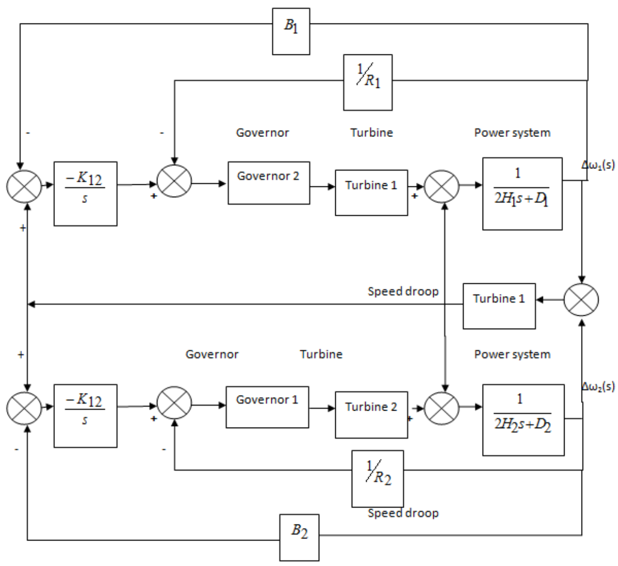

Fig.7 Complete Block diagram representation of Multi Area

6. GENETIC ALGORITHM IMPLEMENTATION

Genetic algorithms are optimization technique, which is inspired by natural selection and natural genetics. It differs from other technique by providing number of candidate solution rather than one candidate solution. Each candidate solution of problem is represented by individual. Population is defined as group of individuals. The process of GA is initialized with a population of random guesses. GA includes operators such as reproduction, crossover, mutation, inversion. The different Genetic Algorithm parameters are listed *below*.

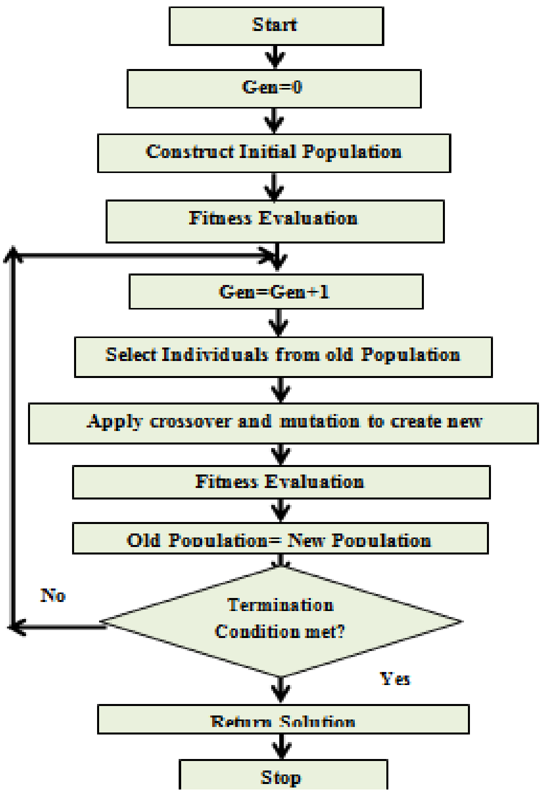

Fig. 8 Flow Chart of Genetic Algorithm

Table 1 Genetic Algorithm Parameters

Population Size	10
Maximum number of Generation	50
Length of genotype	6
Crossover probability	0.8
Mutation probability	0.001

Here, multiple objective function are used which are minimized. The objective function used for the system is given below: Integral square error is given by,

$$ISE = \int_0^{t_{sim}} |\Delta\omega|^2 \, dt$$

7. PROCEDURE FOR GAPSS IMPLEMENTATION

Step 1: "Represent the problem variable domain as a chromosome of a fixed length, choose the size of a chromosome of population popsize (number of individuals), the crossover probability pcross, the mutation probability pm, and the termination criteria maxgen".

Step 2: "Randomly generate an initial population of chromosomes within the specified upper & lower limit values of the parameters. In this work 6 control gains (parameters), [KP1,KI1,KP2,KI2,KP3,KI3] are being tuned for PI control and also for PID 9 control gains [KP1, KI1, KD1, KP2, KI2, KD2, KP3, KI3, KD3] with the help of GA. And here popsize =10 is defined. So, the initial populations of phenotypes are represented in the form of [10 ×6] and [10 ×9] matrix".

Step 3: "Evaluation and selection work on phenotype space, while Genetic operators work on genotype (binary string) space. So, Conversion of phenotypes to binary string is done by decoding every individual created of popsize".

Step 4: "Define a fitness function to measure the performance, or fitness, of an individual chromosome in the problem domain. The fitness function establishes the basis for selecting chromosomes that will be mated during reproduction". The fitness function followed from [21] F_{fit} is defined as follows:

Ffit= min(Ts+Tr+overshoot+ise)

Step 5: "Evaluate the fitness of each individual of population using the fitness function. The objective here is to minimize the fitness function".

Step 6: "Reproduce population of networks (chromosomes) generated according to their fitness".

Step 7: "Select a pair of chromosomes for mating from the current population. Parent chromosomes are selected with a probability related to their fitness".

Step 8:" Create a pair of offspring chromosomes by applying the genetic operators, crossover and mutation".

Step 9:" Insert the created offspring chromosomes in the new population".

Step 10: "Repeat Step 7 until the size of the new chromosome population becomes equal to the size of the initial population, popsize".

Step 11: "Replace the initial (parent) chromosome population with the new (offspring) population".

Step 12: "Go to Step 5, to evaluate new created offspring and repeat the process until the termination criterion is satisfied, maximum number of generation is met (maxgen)".

8. CALCULATION OF CODE LENGTH

For gain KP1:

$$\text{Range } [0\ 10] = (T_1^{max}-T_1^{min}) * 10^4$$
$$= (0-10) * 10^4$$
$$= 100000$$
$$2^{17} < 100000 < 2^{18}$$

So, Length of KP1 =18 and SO ON…

9. SIMULATION

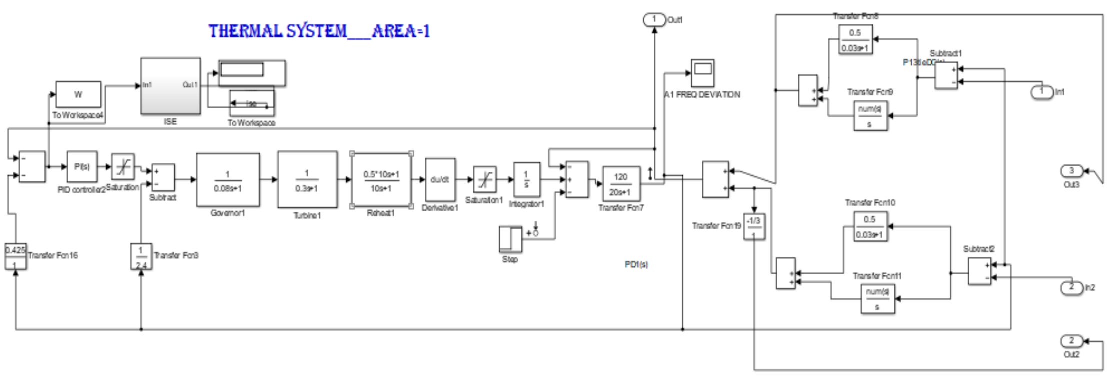

Fig. 9 Simulink model of Area 1 Thermal system

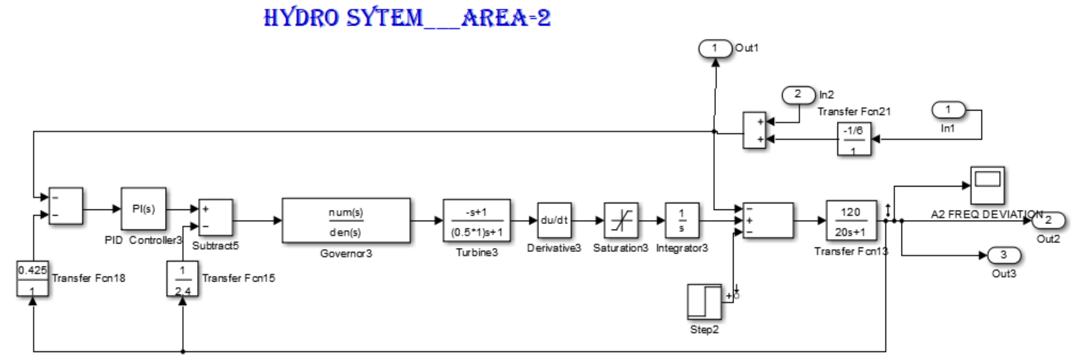

Fig. 10 Simulink model of Area 1 Hydro system

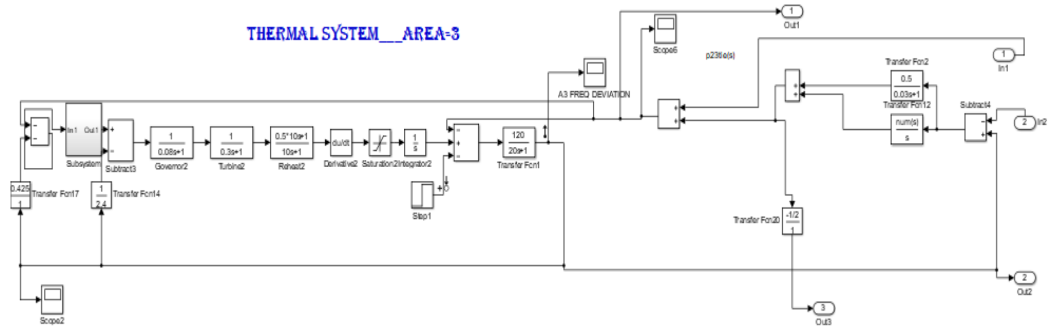

Fig. 11 Simulink model of Area 1 Hydro system

10. RESULTS

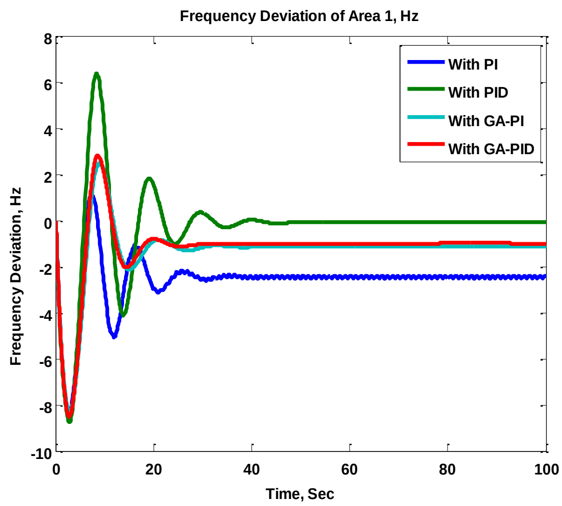

Fig.12 Frequency Deviation of Area 1

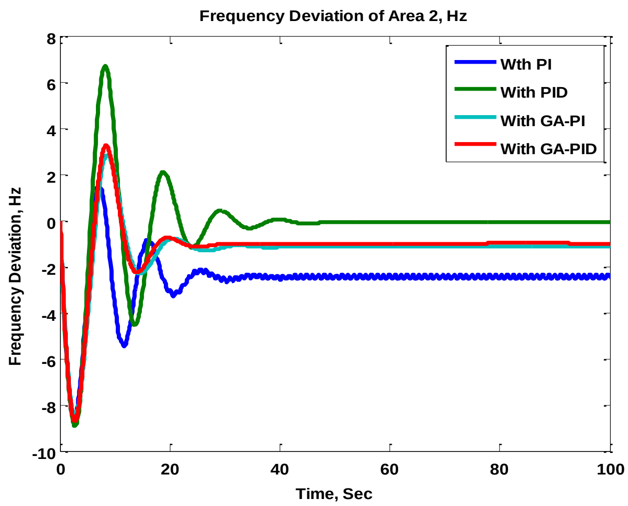

Fig.13 Frequency Deviation of Area 2

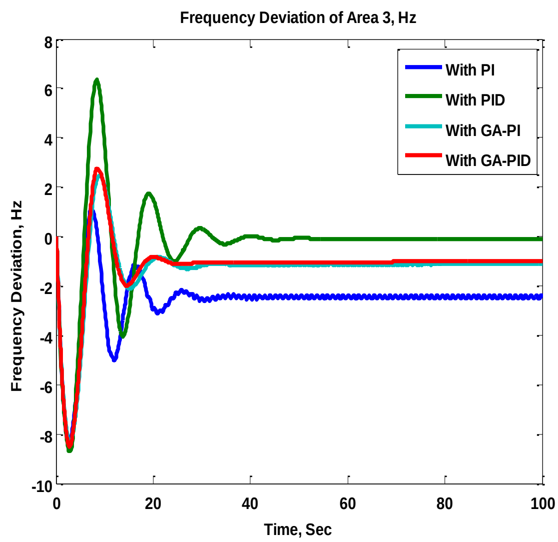

Fig.14 Frequency Deviation of Area 3

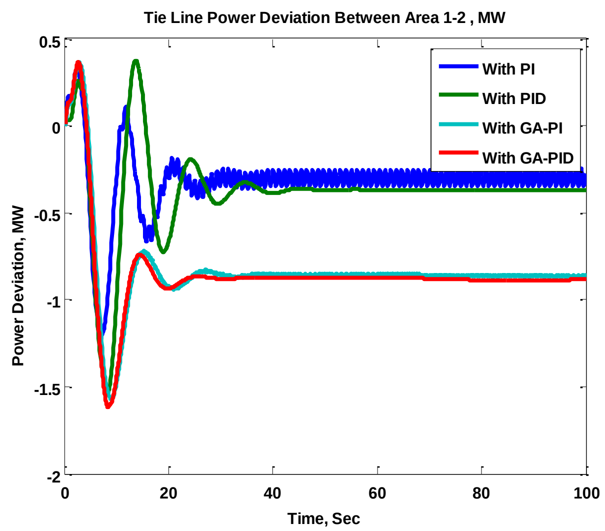

Fig.15 Tie Line Power Deviation Comparisons between Area 1 and Area 2

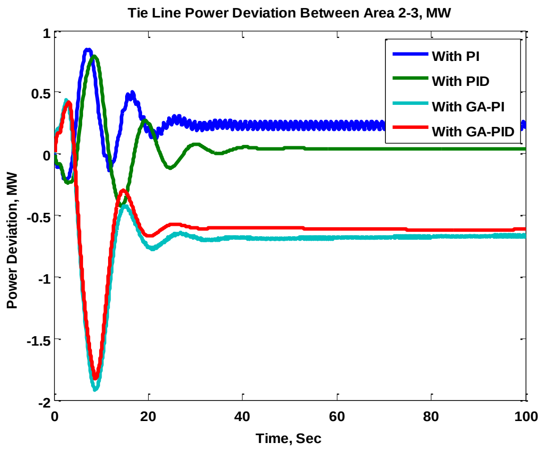

Fig.16 Tie Line Power Deviation Comparisons between Area 2 and Area 3

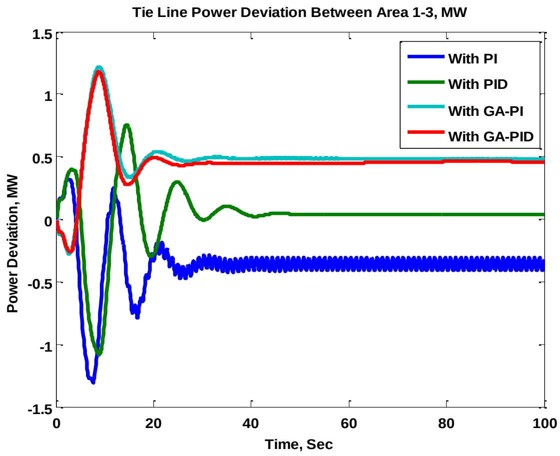

Fig.17 Tie Line Power Deviation Comparisons between Area 1 and Area 3

11. CONCLUSION

The effectiveness of the genetic algorithms is tested on a three area system operating with LFC for several of operating points. These systems are comparing for without and with genetic algorithms. This comparison shows that genetic algorithms give efficient output. It gives less distortion in output frequency and gives more output power in fewer time limits. Less time to settle the excursions of system state variables within acceptable limits. The system response rise time, maximum deviation and settling time of improve when prefer PID tuned GA technique.

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