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Optimization of Load Frequency Control of Different Area System Based on Genetic Algorithm

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Abstract:- Load frequency regulation (LFC) is an essential part of a power system's operation in order to maintain the balance between generation and load demand. This article proposes two unique models for a single area and two area power system that uses a Genetic Algorithm (GA) and a Proportional-integral-derivative (PID) controller. A comparison between the proposed GA-PID controller and the conventional PID controller is made. The simulation results show that the GA-PID controller significantly improves LFC performance by reducing overshoots and settling time while maintaining frequency variation within acceptable boundaries. The recommended approach is further tested under various operational conditions and disturbances, demonstrating its robustness and effectiveness in maximizing LFC. The results demonstrate that the GA-PID controller outperforms the conventional PID controller and can maintain the stability and reliability of the power system. Overall, the proposed GA-PID controller provides a useful and efficient way to optimize the LFC of a power system. The findings of this study can be used to develop LFC strategies that are more advanced and improve the power system's stability and reliability.

Keywords:- *Genetic Algorithm, Load Frequency Control, PID Controller.*

I. INTRODUCTION

The LFC is a vital part of operating a connected power system because it maintains the balance between the supply and demand of electricity. LFC requires a balance between power generation and load demand in an interconnected power system. The power output of the generators may be changed to control the frequency deviation of the LFC system. In order to regulate frequency fluctuation within the constraints of the power system, the LFC problem may be presented as an optimization problem. Researchers have examined the use of optimisation techniques such as GA to design controllers for LFC. The widespread use of GA-based controllers for LFC has sparked a lot of attention due to their ability to manage the nonlinear and dynamic nature of power systems and adjust control settings for greater performance [1].

GA is a type of optimisation algorithm that is impacted by natural selection. GAs are particularly well-suited to dealing with challenging optimisation problems, such as the LFC problem in power systems. The main concept behind using GAs for LFC is to use the GA to find the best controller settings that minimize frequency deviation. In the GA, the controller parameters may be represented as a chromosome, and the fitness function can be expressed as the frequency deviation. The GA repeatedly generates a population of potential solutions and evolves the population using selection, crossover, and mutation operators until the optimal solution is determined [2-3].

II. LITERATURE REVIEW

An overview of the most current studies on GA-based controllers for LFC is the objective of this literature review. The authors of [4] use local optimisation and a particle swarm technique to examine the optimum of semi-active suspension lqr parameters. Wang used the generalized gradient technique to improve the air springs. People provide a multi-objective optimisation technique for information control timing that employs a genetic algorithm to solve it and takes into consideration components such as delay, passing capacity, and parking frequency to design a model [5]. The authors of [6] proposed a distributed and coordinated voltage and frequency (V-f) control system for island microgrids that takes into consideration demand that is dependent on V-f and the restricted capacity of distributed energy resources (DERs). The Non-dominated Sorting Genetic approach II (NSGA-II) methodology and costs are used to evaluate communication system latency, ultra-capacitor size, and secondary controller parameters [7]. For LFC applications, a supervisory adaptive model predictive control (AMPC) technique based on extremely low rating SMES is presented [8]. An optimisation approach based on the CS algorithm is created and used in a nonlinear magnetic levitation system to adjust all FLC parameters, including the RB [9]. An islanded microgrid (MG) employs sliding mode control (SMC), also known as fractional order SMC

(FOSMC), for load frequency control (LFC), which is based on the fractional calculus (FC) concept [10].

The major objective of [11] was to develop a control strategy for HVAC systems that incorporated fan coil unit (FCU) temperature management for energy savings in chilled water systems in order to increase the efficiency of HVAC system operation. The monitoring platform's improved multi-population genetic algorithm (IMPGA), which has many goals, is used to determine which switching technique is the most efficient [12]. The authors of [13] examine power quality issues at an offshore wind-powered oil and gas facility using an island configuration. In [14], the authors present a self-contained, interconnected hybrid microgrid system that uses a sea wave generator, a biodiesel generator, and a battery energy storage system in microgrid 1, and an organic Rankine cycle-based solar thermal power plant, a biodiesel generator, and superconducting magnetic energy storage in microgrid 2. [15] illustrates a practical control method for improving frequency stability in a three-area power system with high penetration of wind energy. The problem of spectral PRB allocation and spatial stacking in a heterogeneous network is still unresolved. The authors of [16] look at a power consumption model for a multi-cell multi-user massive MIMO 5G network to account for the combined effects of both dimensions.

Hence there is an urgent need for optimizing the load frequency control, and genetic algorithms are one of the most promising techniques for this.

➢ *Following are the major contributions of this work:*

- *Proposed a novel electrical model*
- *Analyzed the electrical model in terms of frequency deviation with and without PID controller*
- *Analyzed the effect of genetic algorithms on load frequency control.*

III. PROPOSED SYSTEM MODEL

The proposed system model is shown in Fig. 1 and Fig. 2. Fig. 1 presents a single area power system, on the other hand Fig. 2 presents two area power systems. Further the LFC of this model is analyzed after incorporating PID controller and GA.

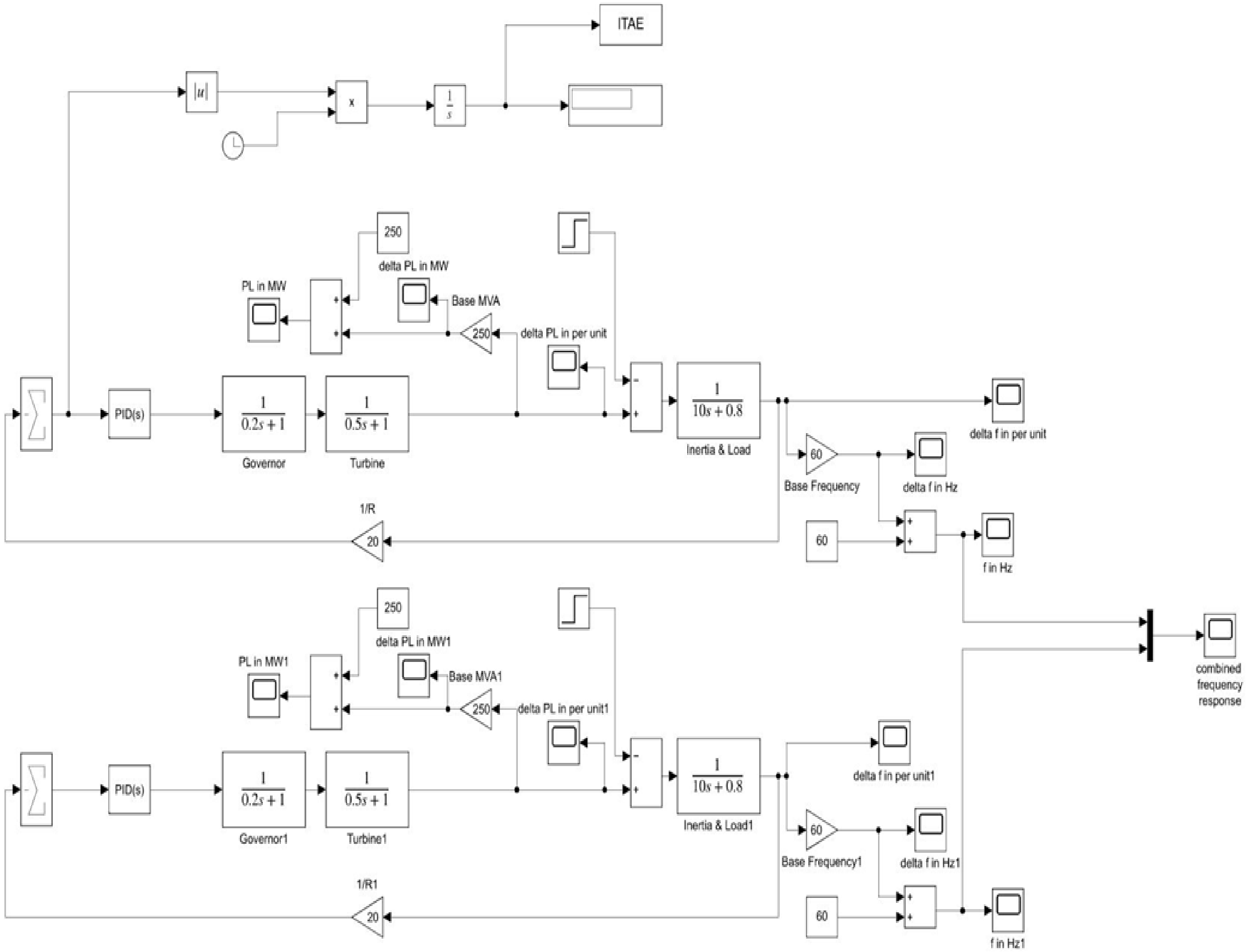

Fig 1 Single Area Power System

A. Genetic Algorithm

Genetic algorithms are becoming a key technique for resolving optimization problems in electrical engineering. They have the ability to address complex optimisation problems that are challenging for traditional optimisation techniques. The many uses of genetic algorithms in electrical engineering include power systems, control systems, and circuit design. By accurately simulating the processes of natural selection and genetic inheritance, genetic algorithms can be used to optimize the parameters in electrical systems to provide higher performance and cheaper costs.

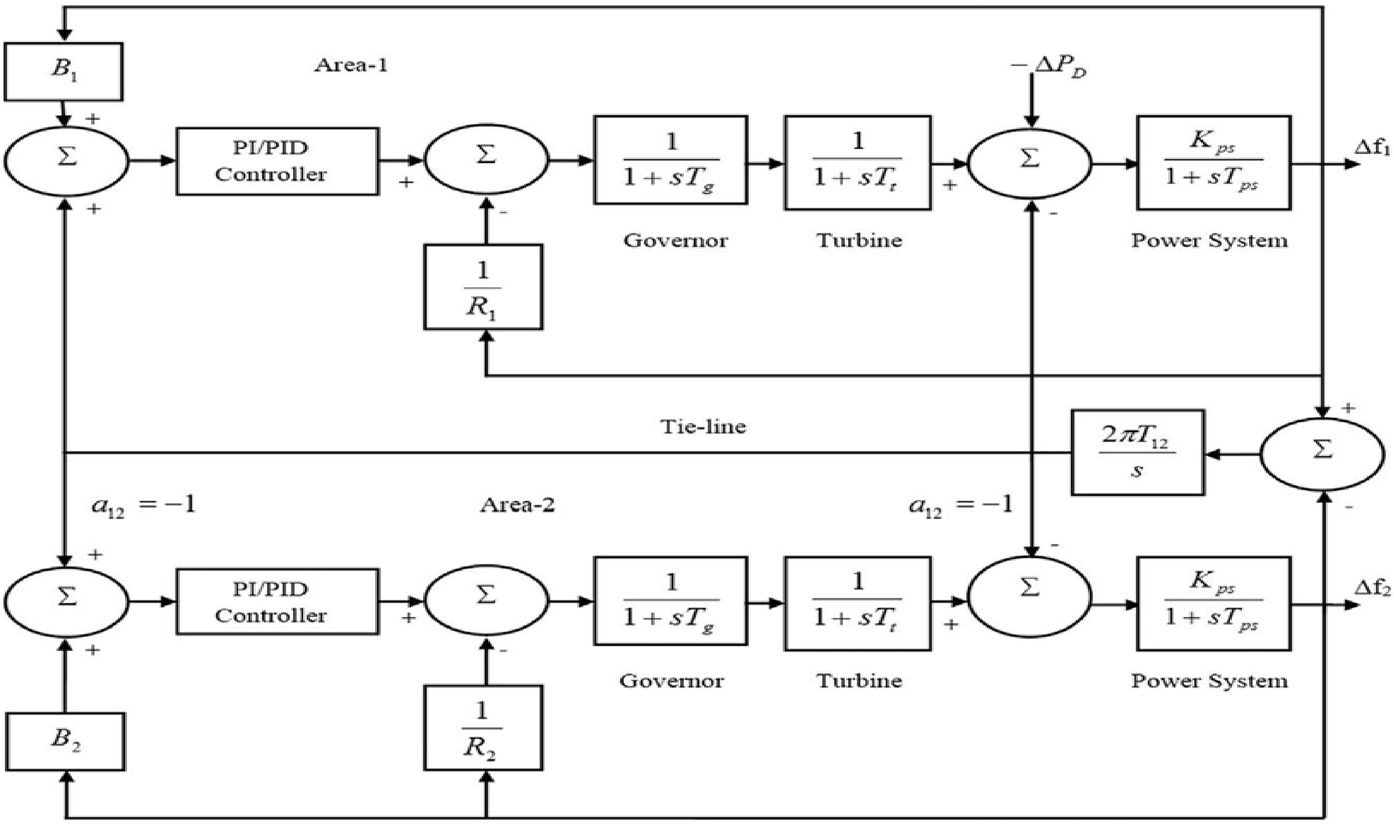

Fig 2 Two Area-Interconnected Power System

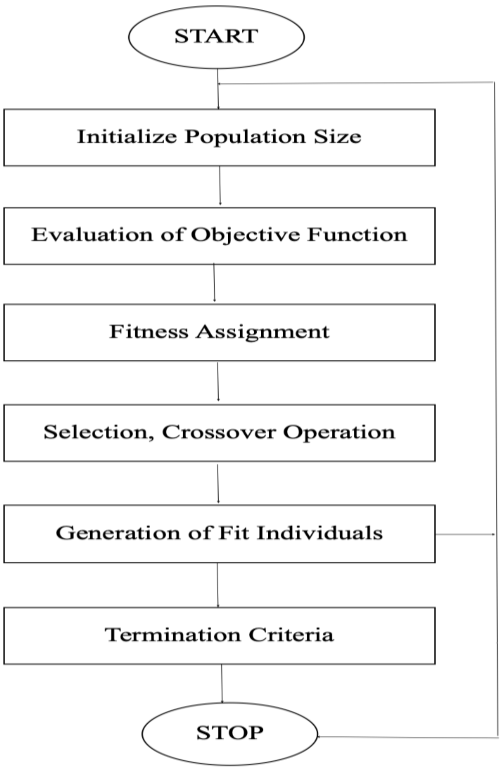

Fig 3 Flowchart of Genetic Algorithm

Before using a genetic algorithm, it is necessary to define the problem and the objective function. The fitness function is defined next, and it is then used to evaluate each solution's performance. The genetic algorithm then carries on with selection, crossover, and mutation in order to produce a new population of answers. The best solutions are selected during the selection process from the current population based on their fitness scores. The crossover approach involves selecting two solutions at random from the population, exchanging a portion of their genetic makeup to create two new offspring, and then repeating the process twice. The process of mutation results in arbitrary changes to the chromosomes of the progeny. The steps of selection, crossover, and mutation are carried out repeatedly until an appropriate response is found. Each stage of the GA is presented in Fig. 3, and explained below.

Prior to using a genetic algorithm, the task and objective of the function must be determined. This requires choosing which variables will be optimized as well as outlining the conditions that must be satisfied. After the problem is specified, the evolutionary algorithm produces an initial population of solutions, each represented by a series of binary digits. The fitness function, which is discussed next, is then used to evaluate each solution's performance. The fitness function is frequently expressed as a function of the objective function, which evaluates the efficacy of each solution. The fitness function assigns a fitness value to each solution based on how well it operates, and the solutions with higher fitness values are selected for further optimisation.

The genetic algorithm then carries on with selection, crossover, and mutation in order to produce a new population of answers. Throughout the selection process, the best candidates are selected from the current population based on their levels of fitness. The crossover process involves randomly selecting two solutions from the population and exchanging a portion of their genetic material to create two new offspring. The mutation process involves randomly changing some of the bits in the chromosomes of the offspring. The process of selection, crossover, and mutation is repeated until a satisfactory solution is found. In electrical engineering applications, the genetic algorithm can be used to optimize parameters such as circuit design, power system operation, and control system design. For example, in circuit design, the genetic algorithm can be used to optimize the values of resistors, capacitors, and other components to minimize power consumption or improve performance.

B. PID Controller

Proportional-integral-derivative (PID) controller is widely used in electrical applications, a well-liked feedback control mechanism, to regulate and control a variety of systems, including power systems, motor speed control, temperature management, and many others. The PID controller algorithm generates an error signal by comparing the desired set point value with the actual output value, and then it sends a control signal in an effort to lessen the error signal.

The PID controller computes the control signal using proportional, integral, and derivative control actions. The proportional action, which is proportionate to the error signal, is used to correct the error in real-time. The integral action, which is proportionate to the error over time, is used to correct steady-state errors. The derivative action is proportionate to the pace at which the error is evolving and forecasts how the system will behave in the future.

IV. RESULT & DISCUSSION

The performance of the system model proposed in Fig. 1 is analyzed under various conditions, in terms of frequency deviation Vs time plot. The frequency is taken in hertz (Hz) and time in seconds.

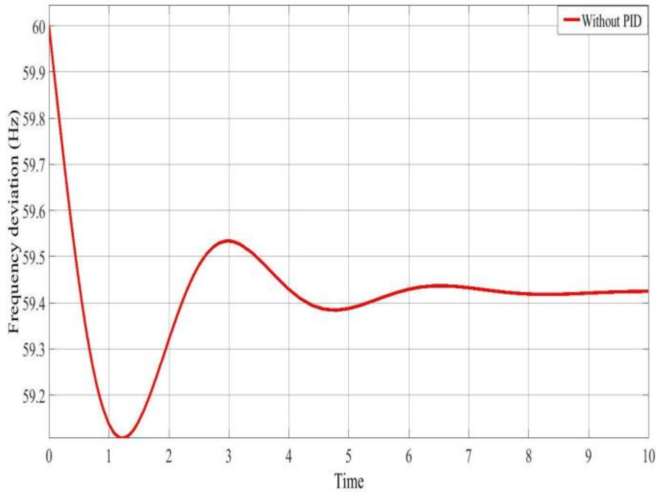

Fig 4 Frequency deviation subjected to load change without PID controller

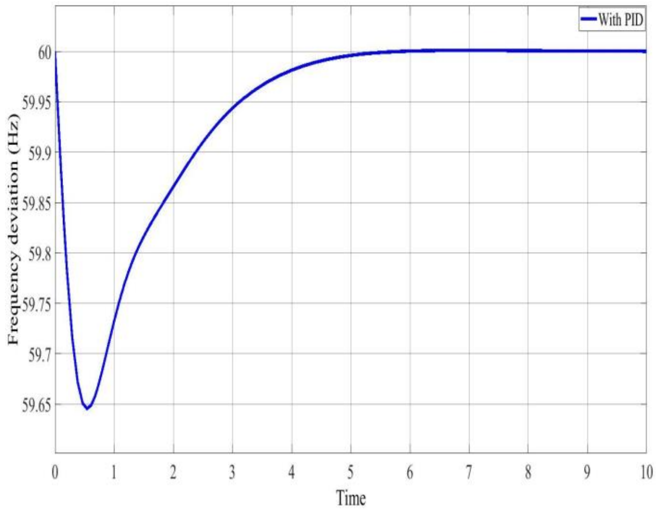

Fig 5 Frequency deviation subjected to load change with PID controller

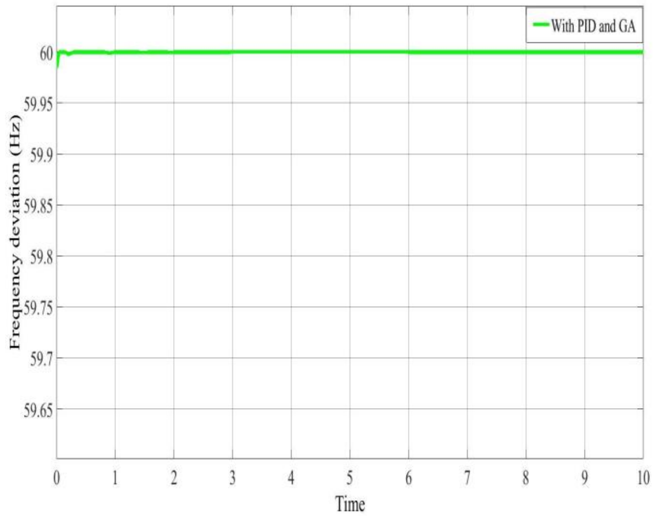

Fig. 6 Effect of GA on Frequency deviation subjected to load change with PID controller

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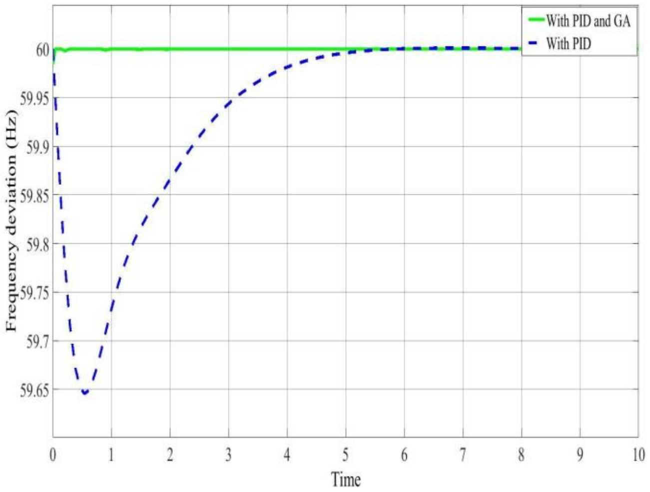

Fig 7 Comparative analysis of Frequency deviation subjected to load change with and without GA for one area network

Fig. 4 and Fig. 5 illustrate the frequency deviation graph of the proposed model with and without PID controller. Severe inconsistency and noise has been observed in models without PID controllers, however after using the PID controller a significant change is observed in the frequency output. But still, this output is not up to the mark and cannot be utilized in any physical application due to high risk of system failure and energy loss. Thus, in Fig. 6 GA is utilized. GA is a popular technique used to improve the system performance by utilizing the basic biological concepts. After incorporating GA and PID controllers into the proposed system model, a straight line is obtained which shows very less or no noise in the frequency output.

Further, Fig. 7 and Fig. 8 presents the comparative study between different models. In Fig. 7 the model frequency output with PID controller and GA is compared. It is very clear that utilizing GA and PID together completely outperformed the output of PID alone.

V. CONCLUSION

In this paper the load frequency controller of a single area and two area power system is analyzed. Because of high power requirements and with growing need of energy, it is of significant importance to optimize the load frequency control of the electrical system. Novel power models for one area and two area power systems are produced in this work, and its performance is analyzed in terms of frequency deviation response. The proposed models are analyzed with different combinations including individual model, model with PID controller, and model with PID controller and genetic algorithm. It is observed that response with genetic algorithms showed most promising results, and it is appropriate for industry. All the simulations are performed on Matlab and Simulink. Moreover, in future the proposed model can be analyzed with Thyristor Controlled Phase Shifter and other controllers.

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