Ant Colony Optimization Algorithm Based PID Controller for LFC Of Two Area Power System

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Abstract— ***The project proposes a novel Artificial Intelligence technique known as Ant Colony Optimization (ACO) for optimal tuning of PID controllers for load frequency control. The design algorithm is implemented within a hydrothermal power system that comprises two control areas: one for hydroelectric power and the other for thermal power with a reheat stage. To ensure that the system accurately reflects real-world conditions, various nonlinearities such as the Generation Rate Constraint (GRC) and Dead Band are incorporated, alongside a broad spectrum of parameters. Three different cost functions have been suggested for tuning the PID controllers. The system has been tested for various load changes to reveal the effectiveness and robustness of the proposed technique.***

I. INTRODUCTION

In the large scale electric power systems with interconnected areas, Load Frequency Control (LFC) plays an important role. The LFC is aimed to maintain the system frequency of each area and the inter-area tie line power within tolerable limits to deal with the fluctuation of load demands and system disturbances. These important functions are delegated to LFC due to the fact that a well-designed power system should keep voltage and frequency in scheduled range while providing an acceptable level of power quality. A wide variety of different advanced control methods have already been proposed in the literature for LFC. Usually LFC is organized in three levels:

Primary control is done by governors of the generators, which provide immediate action to sudden change of load.

Secondary control keeps frequency at its nominal value by adjusting the output of selected generators (controller is needed).

Tertiary control, a vital aspect of economic dispatch in power systems, aims to optimize operations for cost efficiency. Over the years, extensive research has focused on Load Frequency Control (LFC), a critical component of power system stability. Two prominent approaches involve robust LFC designs utilizing H-infinity ($H\infty$) and H2 control theories. Despite their effectiveness, these methods have a drawback: they introduce controllers with the same order as the plant, thereby doubling the open-loop system's order. This complexity can pose challenges, especially in large interconnected power systems.

Alternatively, a different technique proposes tuning the parameters of a Proportional-Integral-Derivative (PID) controller for LFC in a single-area power system using Particle Swarm Optimization (PSO). This method seeks to optimize controller settings to achieve desired performance without inflating system complexity.

Genetic Algorithm also used in this field for the purpose of selection of PID parameters. In LFC with fuzzy logic controller (FLC) considering nonlinearities and boiler dynamics is introduced which has greatly improved the performance of the controller. In new approach using Imperialist Competitive Algorithm (ICA) for multi area LFC has been introduced.

This project introduces a new Artificial Intelligence (AI) technique (ACO) for optimal tuning of PID controllers.

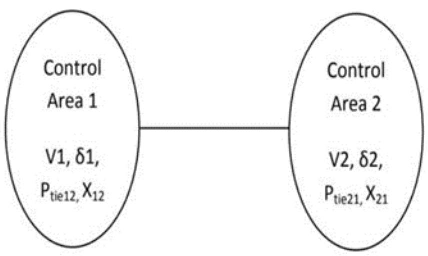
II. OBJECTIVE

The main objective of load frequency control is to maintain the balance between the generation and consumption of electrical power in a power system. The two-area load frequency control system consists of two interconnected areas that share power. The goal is to regulate the frequency and tie-line power between these areas within acceptable limits.

III. METHODOLOGY

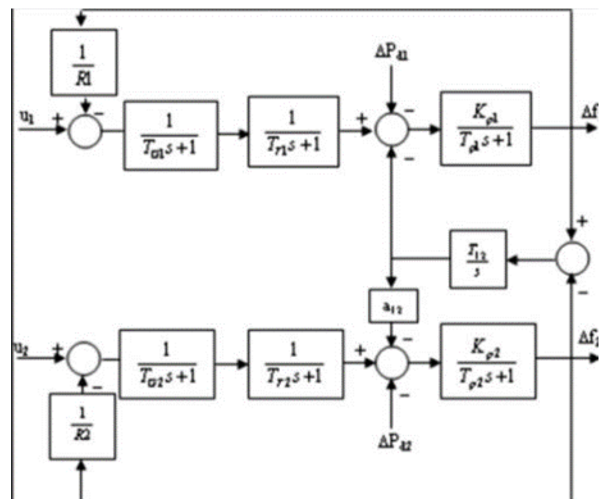
A. Working:

Two-area load frequency control (LFC) is a method used in interconnected power systems to regulate the frequency deviations in different areas by adjusting the generation levels. Each area consists of its own set of generators and loads. The goal is to maintain the system frequency within acceptable limits despite changes in load demand or generation. Ant Colony



Optimization (ACO) is a metaheuristic algorithm inspired by the foraging behavior of ants. It's used for optimization problems and is particularly effective in complex, nonlinear systems. In the context of LFC, ACO is utilized to fine-tune the parameters of Proportional-Integral-Derivative (PID) controllers. PID controllers are widely used in control systems. They consist of three terms: Proportional (P), Integral (I), and Derivative (D). These terms act based on the error signal between the desired and actual frequencies to adjust generator outputs accordingly. A well-tuned PID controller can improve the system's response time, stability, and overall performance. The integration of ACO with PID controllers offers several benefits. Firstly, it automates the tuning process, eliminating the need for manual adjustment of PID parameters. This not only saves time but also ensures optimal performance under varying operating conditions. ACO's ability to explore complex solution spaces makes it suitable for handling the nonlinear dynamics of power systems. In a two-area LFC system using ACO-tuned PID controllers, the ACO algorithm optimizes the PID parameters based on predefined performance criteria. These criteria typically include factors such as settling time, overshoot, and steady-state error. Once the optimal parameters are determined, the PID controllers adjust the generator outputs in response to frequency deviations, helping to stabilize the system and maintain the desired frequency. Overall, the integration of ACO-tuned PID controllers in two-area LFC systems represents a sophisticated approach to enhance the stability and efficiency of power systems. By leveraging the strengths of both ACO and PID control, this method improves frequency regulation in interconnected grids, ensuring reliable operation even in the face of dynamic changes in load and generation.

B. Circuit Diagram



The aim of implementing a two-area load frequency control (LFC) system using an Ant Colony Optimization (ACO) tuned PID controller is to regulate the frequency and tie-line power flow between two interconnected areas in an electrical power system. This aims to maintain system stability by adjusting the power output of generators in response to changes in load demand or disturbances. The ACO algorithm is utilized to optimize the PID controller parameters, such as proportional, integral, and derivative gains, to achieve improved performance and robustness in the LFC system.

C. Result And Model

Using an Ant Colony Optimization (ACO) tuned PID controller for two-area load frequency control can yield improved system performance compared to conventional methods. ACO helps optimize PID parameters to enhance system stability, reduce settling time, and minimize overshoot. The specific results would depend on the initial system dynamics, tuning parameters, and optimization criteria. Typically, you'd expect to see smoother frequency response, faster settling times, and better disturbance rejection with ACO-tuned PID controllers compared to manually tuned ones.

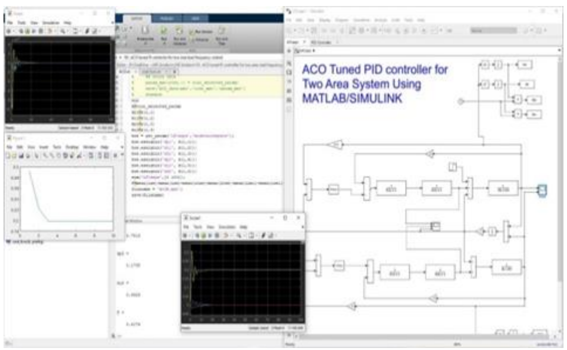


Fig. ACO Tuned PID Controller for Two Area Load Frequency model

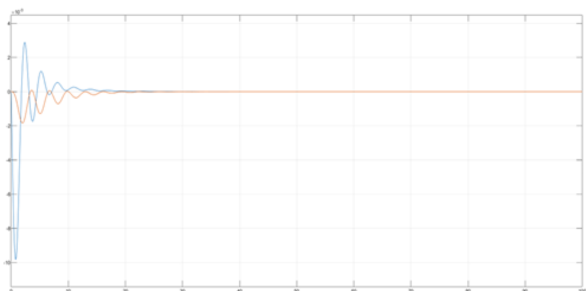


Fig. Change in frequency in area 1 and area 2

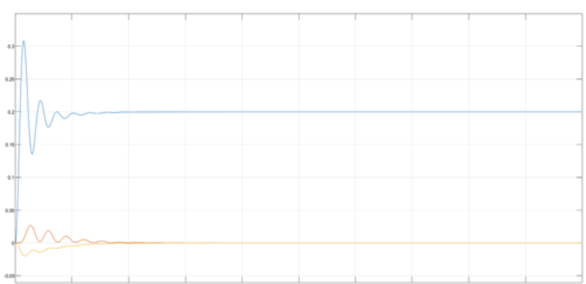


Fig. Rate of change of time of power flow

CONCLUSION

In this project report, a PID controller which is tuned via ACO has been strongly proposed for the multi area LFC problem. The results declared that ACO based PID is capable to guarantee robust stability and robust performance under various load in conditions and change system parameters for three different cost functions. The proposed controllers succeeded in damping all oscillations, minimizing settling time and reducing overshoot, this reduces wear in control valves and gates. In the future work we intend to apply the ACO algorithm to the renewable energy power stations as wind turbine for example; also we intend to specify the upper limit of load disturbances which may cause the instability problem of the power system.

REFERENCES

[1] D.K. Premkumar, B. Manikandan and A. Kumar, "Antlion Algorithm Optimized Fuzzy PID Supervised On-line Recurrent Fuzzy Neural Network Based Controller for Brushless DC Motor," Electr. Pow. Compo. Sys., vol. 45, pp. 1-14, Mar. 2018.

[2] M. Gheisarnejad, "An effective hybrid harmony search and cuckoo optimization algorithm based fuzzy PID controller for load frequency control," Appl. Soft Comput., vol. 65, pp. 121-138, Apr. 2018.

[3] S. Kayalvizhi and D.M. Vinod Kumar, "Load Frequency Control of an Isolated Micro Grid Using Fuzzy Adaptive Model Predictive Control," IEEE Access, vol. 5, pp. 16241-16251, Aug. 2017.

[4] H. Iranmanesh and A. Afshar, "MPC-Based Control of a Large-Scale Power System Subject to Consecutive Pulse Load Variations," IEEE Access, vol. 5, pp. 26318-26327, Nov. 2017

[5] R.K. Avvari, R. Kotturi and V.A.R. Ganta, "A Bip 2arametric variation (Tt-Tg) degrades the performance of TDF-IMC scheme for load frequency control," Proc. 2017 Innovations in Power and Advanced Computing Technologies (i-PACT), Vellore, India, 2017.