IDEAL SCHEMING OF LFC LOOP OF HYDRO-THERMAL SYSTEM CONNECTED TO WIND FARM BY USING FUZZY-PID CONTROLLER THROUGH HVDC LINES

A. Anjaiah[1] Dr.K. Raju[2]

A. Anjaiah, *Assistant Professor EEE, Tkr College of Engineering &Technology (Autonomous), India*

Dr.K.Raju, *HOD and Assistant Professor EEE, Tkr College of Engineering &Technology (Autonomous), India*

P. Chaitanya Kumar, *UG student, EEE, Tkr College of Engineering &Technology (Autonomous), India*

M. Sai Deepak Reddy, *UG student, EEE, Tkr College of Engineering &Technology (Autonomous),India*

N. Tharun , *UG student, EEE, Tkr College of Engineering &Technology (Autonomous), India*

P. Prudvi Raj , *UG student, EEE, Tkr College of Engineering &Technology (Autonomous),India*

Abstract*— Stable frequency maintenance is essential for contemporary linked electrical power networks. In order to guarantee that the frequency deviation stays constant despite ongoing load fluctuations, load frequency control, or LFC, is essential. The optimization of LFC for a two-area power system with various control schemes is the main goal of this research.Maintaining the frequency deviation when various sorts of areas are interconnected is the primary function of the load frequency control.The many forms of energy produced cause the frequency to become unstable, which might result in Here, we employed a variety of controlling techniques. In order to manage the frequency change close to the stable frequency and optimize the PID values for better performance, we employed fuzzy-PID and PID controllers together with algorithms.To improve the PID values, we employed particle swarm optimization (PSO) and genetic algorithms (GA). In order to increase the system's economy and efficiency, we must use controllers and optimization techniques to enhance its performance. To ensure steady power system performance, load frequency control, or LFC, is essential. It guarantees that even under different load situations, the frequency deviation stays within allowable bounds. To improve LFC performance, researchers have recently investigated a variety of optimization strategies.

***Keywords*—** Load Frequency Control(LFC), Fuzzy Control,Fuzzy-Pid,Genetic Algorithm(GA),Particle Swarm Optimization(PSO)

I. INTRODUCTION

Power imbalances between generation and demand, which result in the transfer of power between various locations, are typically the source of frequency variation in power systems. The load frequency control (LFC), which attempts to restore the frequency and interchanging power to their planned proportions, is seen to be a significant response to this imbalance in this case. New smart systems with a variety of energy resources are necessary due to the rise in power consumption as well as the expansion and complexity of the power system. In order to maintain the frequency and interchanging power in predetermined quantities against a wide variety of disturbances, researchers are actively looking for innovative ways for LFC. A critical analysis of the literature on power systems' AGC has been published, including many areas of LFC control.

But a lot of contemporary techniques, like the ones listed above, need a level of sophistication that restricts their applicability. As a result, using traditional PI and PID controllers is recommended as they have benefits including a straightforward design and high performance. Furthermore, intelligent algorithms are employed in certain publications to optimize the settings of PI/PID controllers. Transmission lines connected the control areas that comprised the power systems. Maintaining frequency stability is essential to the power system's improved performance. The load control loop plays a crucial role in maintaining frequency stability and longevity in power plant generators. Frequency control stabilizes the synchronous and induction motors' speeds. The usage of renewable energy sources in power networks, such as wind and hydropower, has grown dramatically in recent years. By adjusting the intake valve of the water turbine, hydraulic plants' productivity may be measured. The frequency regulation will become more difficult when the electricity grid is linked to a wind farm. Due to the fact that wind speed affects wind farm productivity, frequency oscillations in the power system will result. To keep the system frequency within the limit, the controller must be used in a load-frequency control loop with a high reaction speed. Four categories may be used to group research on load-frequency controller design in power systems: resilient control, intelligent control, adaptive control, and classical control approaches. This section examines a some of the most eagerly awaited pieces over the past few years.

II. FORMULATION OF THE PROBLEM

All functional components must be accurately model for LFC investigations pertaining to the power systems. This section presents the model of the power system under study, followed by the suggested Fuzzy-PID controller is presented. The suggested objective function (OF) is finally given. Figure 1 depicts the transfer function of the two-area power system being studied. Each area ACE has one thermal unit and one hydro unit. Figure 2 illustrates the intended system transfer function.

THE PROPOSED CONTROLLER

The proposed controller is a fuzzy PID hybrid control, where fuzzy components and controller values were taken into account using the The Relevant power system model (FIG-1).

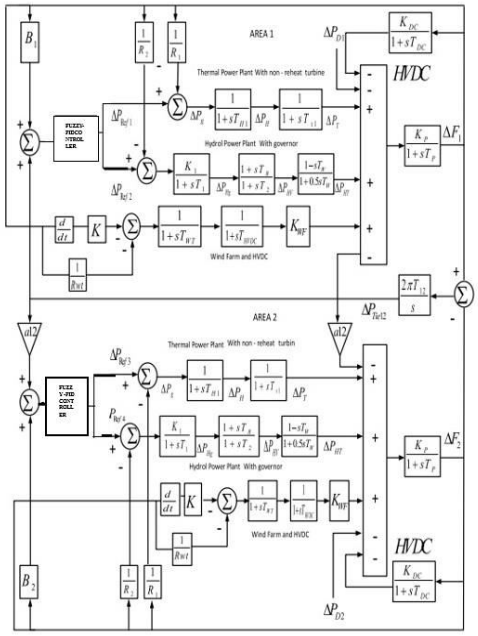
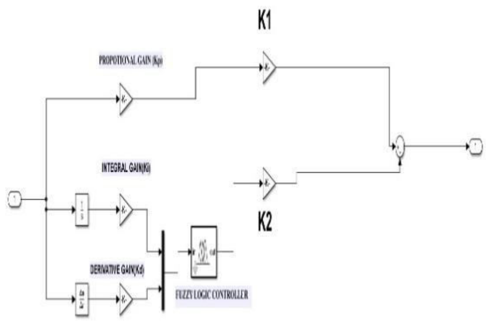


FIG-1:- **RELEVANT POWER SYSTEM MODEL**

The proposed F-PID controller is shown in FIGURE 2.



FIG–2:-Proposed F-PID controller

Fuzzy controllers are used in power system fading as reliable stabilizers. This paper examined the use of a fuzzy PID controller to stabilize the frequency in the system under study. Fuzzy logic is used to modify the fuzzy PID controller coefficients according to the recommended controller performance [52]. When a fuzzy controller is used before a PID controller, the fuzzy controller modifies the PID control coefficients under various loading circumstances to improve performance.

$$ACE_i = B_i \Delta f_i + \Delta P_{tie}$$

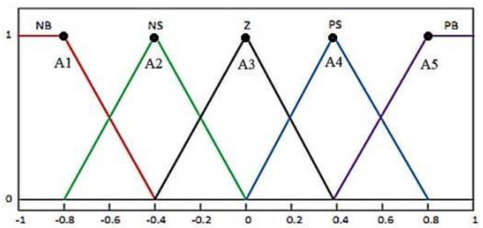


FIG-3 TWO INPUTS AND ONE OUTPUT MEMBERSHIP FUNCTIONS

Fig-3 illustrates three membership functions for controller inputs and outputs: triangular-type (NS and PS) for small negative and positive changes, and trapezoidal (NB and PB) for large negative and positive changes applied. Table 1 shows the range of variations for these five coefficients.

Table – 1 Variations in the fuzzy control coefficient range.

Coefficient	A1	A2	A3	A4	A5
Interval	[-1 -0.5]	[-0.5 -0.1]	[-0.1 -0.1]	[0.1 0.5]	[0.5 1]

Fuzzy rule for the proposed controller is given in Table-2

Table-2:- Fuzzy-PID controller fuzzy rule table.

ERROR (E)	CHANGE IN ERROR ($\overline{E}$)				
	NB	NS	Z	PS	PB
NB	NB	NB	NB	NS	Z
NS	NB	NB	NS	Z	PS
Z	NB	NS	Z	PS	PB
PS	NS	Z	PS	PB	PB
PB	Z	PS	PB	PB	PB

This work aims to use a genetic algorithm to manage the load frequency of a two-area thermal system. GA And PSO controls the PID controller settings. Its parameters To minimize the error function, use proportional constants Kp, KI, and Kd. This work's error function is the Integral Time of Absolute Error (ITAE). The equations are

$$J = \int_0^{t_1} (|\Delta f_1| + |\Delta f_2| + |\Delta p_{tie}|).t$$

$$\Delta f_1^{min} \leq \Delta f_1 \leq f_1^{max}$$

$$\Delta f_2^{min} \leq \Delta f_2 \leq f_2^{max}$$

$$\Delta p_{tie}^{min} \leq \Delta p_{tie} \leq \Delta p_{tie}^{max}$$

Where

Δf_1 = change in frequency of area-1

Δf_2 = change in frequency of area-2

Δp_{tie}= change in tie line power

III. Techniques for Intelligent Control

Optimization is the mathematical process of determining the minima and maxima of a function under certain restrictions.Today, optimization includes a wide range of Various methodologies from operations research, artificial intelligence, and computer science are utilized to enhance business processes across sectors.Optimization is the process of determining the optimal solution.Mathematical programming, also known as optimization modeling, aims to identify the optimal solution to a problem. Various strategies have been offered to regulate this problem.

The challenges in LFC include designing a reliable controller and successfully optimizing its settings to

get optimal results.Various optimization methods, including GA, PSO, BFO, DEA, ANN, FLC, and others, are used to solve LFC problems. This thesis proposes a Genetics Algorithm (GA)-based PID controller to solve the optimum LFC problem by addressing frequency and tie line power deviations.
The suggested Genetics Algorithm (GA) And Particle Swarm Optimization has been tested on interconnected two-area thermal power plants. The results show that The suggested Genetic Algorithm (GA) out performs particle swarm optimization in terms of dynamic reaction.

A. GENETIC ALGORITHM

A genetic algorithm is a probabilistic search method that models biological evolution computationally. An outline of the actions the algorithm takes is shown in the flowchart that follows.This approach resembles natural evolution by iteratively adjusting a set of potential solutions until the best one is discovered. The GA evolutionary cycle begins with a randomly chosen beginning population. Populations evolve through fitness-based selection, as well as mutation and crossover.Using selection and change can result in a population with more better solutions.

The evolutionary cycle continues until a viable solution is found in the current generation or a regulatory parameter, such as the number of generations, is surpassed. A gene is the smallest unit in a genetic algorithm, representing a unit of information within the issue area. A chromosome is a collection of genes that provide one possible solution to a problem. Each gene on the chromosome represents a component of the solution pattern.

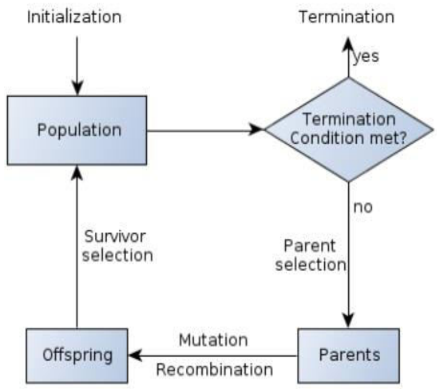


FIG – 4. Flow Chart Of GA

The most frequent way to express a solution as a chromosome is a string of binary numbers. Each byte in this string represents a gene. The technique to transform the solution Coding is the process of converting a unique format into a bit string. The specific coding scheme employed is application-dependent. The solution bit strings are cracked and evaluated based on a fitness metric.
(i) Selection: In biological evolution, the fittest survive and pass on their genes to future generations. Selection in GA follows a similar method. Fitness proportional selection involves selecting chromosomes based on their fitness value.
(ii) Crossover-crossover is a type of artificial mating that involves combining chromosomes from two individuals to generate a new chromosome generation. This involves splicing two chromosomes from separate solutions at a crossing location and switching the resulting sections. Combining excellent genes from one chromosome with those from another can result in a more effective solution represented by the new chromosome.
(iii) Mutation is a random change to the genetic makeup. This method is useful for identifying novel traits in a population, which cannot be obtained with only crossover. Crossover just rearranges existing traits to create new combinations.

B. PARTICLE SWARM OPTIMIZATION

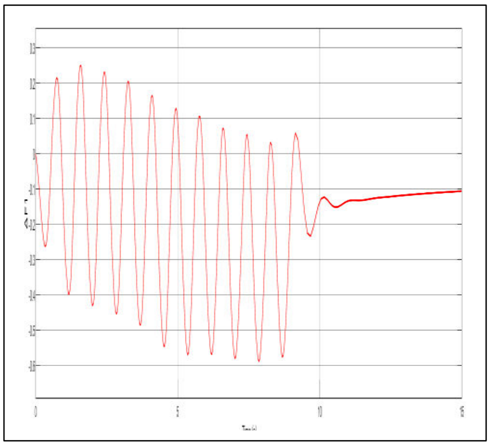
PSO optimization is one of the most effective LFC optimization techniques. It was created in 1995 and is based on bird flocking and fish schooling mapping. It is dependent on the swarms' population. For optimization problems, it requires extremely little processing time and memory. Bird flocking is a technique that is based on how birds go in search of food. They take the shortest route to their goal. The population of swarms is randomly produced in this technique, and the optimal solution in their position is determined using the fitness value. The global value is another excellent option. The particle's position is changed to its best value at the end of each cycle. Every iteration, the particles' velocity is updated. Particle Swarm Optimisation (PSO) is an optimization technique based on the flocking behaviour of birds. It is a population-based optimization method inspired by flock behaviour of birds. PSO method is based on the idea of particles in a search space representing potential solutions. The particles move around the search space, altering their positions based on their current fitness and the best position discovered by their neighbours. The particles can communicate with one another, conveying information about their current location and the optimal place discovered. There are various advantages to using the PSO algorithm over other optimization strategies. It is simple to use and can tackle both continuous and discrete optimization problems. It's also computationally efficient and can handle large-scale challenges. The PSO algorithm has been employed in a variety of applications, including optimal power flow, transient stability, and economic dispatch.

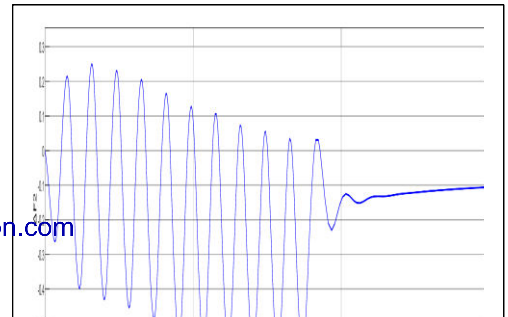
IV. SIMULATION RESULTS

In this paper, using the suggested PID controller is proposed to control the multi-area power system frequency with thermal, hydro and wind units. For optimal designing of the PID gains in controller was applied by Genetic Algorithm and Particle Swarm Optimization In this article, the suggested controller performance designed in two-area power system, with 10% load variation in each area is evaluated. It was compared with other controllers and also various algorithms.

Matlab implementation of two areas (Thermal-Hydro) load frequency control system area control error which is equal to sum of deviation in tie-line power and deviation in area frequency multiplied with frequency bias constant, together with its derivative ACE have been considered as inputs to Particle swarm optimization controller. Then find the GA Technique gives the best result. The thermal-Hydro system is MATLAB implementation.

The embedded MATLAB function only having two inputs first is direct input and second is delay input by last output. MATLAB function is only taking average of these two values so the output function Y is evaluated. This function gives the set value at the time of variation and gives system stability. This MATLAB implementation of two area load frequency control study in different case like tie line bias control, Ziegler-Nichols method and PID tuned GA method.





This work proposes an optimal

Fig – 5 Frequency Deviation of ΔF1,ΔF2 of the system using Fuzzy – Pid Controller

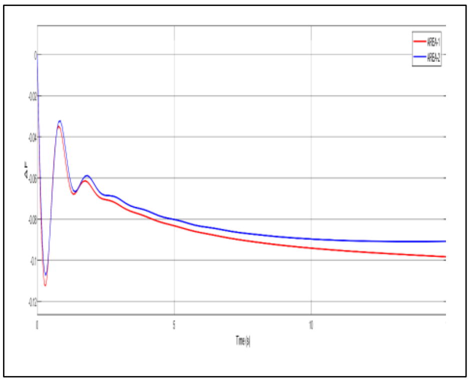


Fig – 6 Frequency Deviation of ΔF1,ΔF2 of the system using PSO – Pid Controller

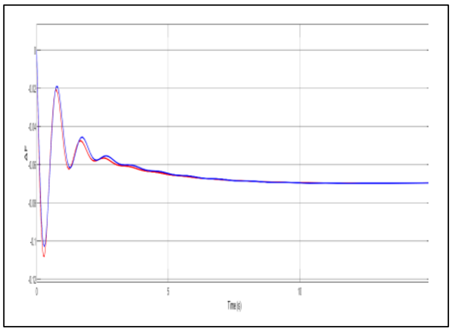


Fig – 7 Frequency Deviation of ΔF1,ΔF2 of the system using GA – Pid Controller

Fig – 8 Genetic Algorithm

Table - 3 Results For Different Controlling Techniques

S.NO	Controller Observed Parameter	WITHOUT CONTROLLER	WITH FUZZY-PID CONTROLLER	WITH GA-PID	WITH PSO-PID
1	$\Delta F1$	-0.3934	-0.1066	-0.06961	-0.09834
2	$\Delta F2$	-0.1102	-0.1057	-0.6961	-0.09074
3	$\Delta Ptie$	-0.7603	0.0004016	-0.003106	-0.2703
4	ITAE	92.44	40.2	15.66	21.88
5	$\Delta PD1$	0.1	0.1	0.1	0.1
6	$\Delta PD2$	0.1	0.1	0.1	0.1

V . CONCLUSION

This work proposes an optimal PID controller for the frequency regulation of the multi-area power system with hydro-thermal units linked to the wind farm. The membership functions and suggested controller parameters are created. Wind farms are used in a single scenario for simulations. Several types of controlling techniques are used in the situations in this project. Outcomes from the various controllers are observed. In comparison to other controlling techniques, the aforementioned project's use of a genetic algorithm produces superior outputs with steady state error, and particle swarm optimization produces better outcomes than a fuzzy-pid controller. Much better results are obtained using the genetic algorithm: ΔF1 = ΔF2 = -0.06961, with a 10% load variation. The PID settings are optimized for the optimization using the algorithms.

The optimized GA-PID has an ITAE Value of 15.66, whereas the optimized PID using Particle Swarm Optimization has an ITAE Value of 21.88. Since these sources will supply a portion of the power deficit byS abruptly boosting the demand in a brief amount of time, the system's frequency deviation will decrease. However, conventional controllers like PID in nonlinear systems, like the power system under study in this paper, performed poorly, and when they were utilized in a load control loop, the frequency amplitude was large. Dampening also requires more time. Amplitude and settling time will go down if nonlinear controllers, such as fuzzy controllers, are used.

REFERENCES

[1] M. Ahmadi Kamarposhti, H. Shokouhandeh, M. Alipur, I. Colak, H. Zare and K. Eguchi, "Optimal Designing of Fuzzy-PID Controller in the Load-Frequency Control Loop of Hydro-Thermal Power System Connected to Wind Farm by HVDC Lines," in IEEE Access, vol. 10, pp. 63812-63822,2022,doi: 10.1109/ACCESS.2022.3183155.

[2] K. Arora, A. Kumar, and V. K. Kamboj, ‘‘Automatic generation control and load frequency control: A comprehensive review,’’ in Applications of Computing, Automation and Wireless Systems in Electrical Engineering. Singapore: Springer, 2019, pp. 449–456.

[3] Mehdi Tavakoli, Edris Pouresmaeil, Jafar Adabi, Radu Godina, João P.S. Catalão,“Load-frequency control in a multi-source power system connected to wind farms through multi terminal HVDC systems”, Computers & Operations Research, Volume 96,2018,Pages 305-315, ISSN 0305-0548.

[4] Rabindra Kumar Sahu, Sidhartha Panda, G.T. Chandra Sekhar, “A novel hybrid PSO-PS optimized fuzzy PI controller for AGC in multi area interconnected power systems”, International Journal of Electrical Power & Energy Systems,Volume 64,2015, Pages 880-893,ISSN 0142-0615,

[5] Regar, Rekha & Jangid, Raunak & Parikh, Kapil. (2017). Load Frequency Control of Two Area System Using Genetic Algorithm. International Journal of Engineering Research and. V6. 10.17577/IJERTV6IS040198.

[6] A. Prakash, S. Murali, R. Shankar, and R. Bhushan, ‘‘HVDC tie-link modeling for restructured AGC using a novel fractional order cascade controller,’’ Electr. Power Syst. Res., vol. 170, pp. 244–258, May 2019.

[7] J. Ansari, A. R. Abbasi, and B. B. Firouzi, ‘‘Decentralized LMI-based event-triggered integral sliding mode LFC of power systems with disturbance observer,’’ Int. J. Electr. Power Energy Syst., vol. 138, Jun. 2022, Art. no. 107971.

[8] J. J. Justo and F. A. Mwasilu, ‘‘Low voltage ride through enhancement for wind turbines equipped with DFIG under symmetrical grid faults,’’ Tanzania J. Eng. Technol., vol. 37, no. 2, pp. 125–136, Jun. 2018.

[9] M. Ranjan and R. Shankar, ‘‘A literature survey on load frequency control considering renewable

energy integration in power system: Recent trends and future prospects,'' J. Energy Storage, vol. 45, Jan. 2022, Art. no. 103717.

[8] D. K. Sahoo, R. K. Sahu, G. T. C. Sekhar, and S. Panda, ''A novel modified differential evolution algorithm optimized fuzzy proportional integral derivative controller for load frequency control with thyristor controlled series compensator,'' J. Electr. Syst. Inf. Technol., vol. 5, no. 3, pp. 944–963, Dec. 2018.