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Automatic Generation Control of a Multi-Source Power System using FOPID Controller by CSA

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Abstract: This paper focused on the automatic generaration control of multi-source power sytem comprising of hydro, thermal, gas units by using fopid controller. The fopid controller has good dynamics as compare to the io, pi, pid controller. Selection of parameters is done with cuckoo search algorithm. The cuckoo search algorithm is used for all of the three systems. Fopid controller controls the overshoot and oscillations of the respective system. The cuckoo search algorithm is robust technique used for the optimization of the parameters
Keywords: Automatic Generation Control, Fraction Order Controller, Cuckoo Algorithm, Fopid Controller.

I. INTRODUCTION

In the power operation and protection, limiting the frequency and voltage in a nominal or predetermined value is one of the major issues that are being faced in this field. Generation power quality and reliability was expected to depend upon the determined balance between the power generated and demanded, combined with the power losses in the whole power system.

There is some deviation caused in power and frequency because of disruption in balance. Some random change in the loads can also be seen due to this disruption. This is the reason, it is recommended to use the proper control method so that overall constancy of power unit can be obtained. Till the time numerous control method exist and used to control the frequency parameter in different power system.

Automatic generation Control may be described as one of necessary controlling technique in interlinked power units to make sure that the operation is efficient and secure. If any variation among power production unit and power consumption unit has been identified then it will result in unwanted divergence in frequency.

Automatic Generation Control is the best strategy to control the system to confirm the operation. If there is any mismatch occurs between generation and demand the frequency changes from its desired value. The primary goal of this strategy is to control the frequency and tie line power flow in interconnected area to its desired value. Therefore in order to achieve it many controllers are introduced in the system. These are integrator controllers, PI, PID, FOPID controllers. All have there own performance values but FOPID controller is the best among all because FOPID gives good dynamics response as compared PI, PID controllers.

There are several control methods like optimal control technique, variable structure control, self tuning etc. some of the industries uses IO, PI based controller. These methods are based on error and trial methods but these controllers have no surety to provide good and improved performance in the realistic conditions like GRC and GDB. So to eliminate these problems new controller was introduced which is based on fractional order that is FOPID controller. This controller is superior than others because it has two extra tuning knobs name as fractional order of integrator and fractional order of differentiator. These knobs provide more flexibility for dynamics performance of the system. The multisource consists of the hydro, thermal, gas units.

There are many methods to solve the automatic generation problems. These methods include particle swarm optimization (pso), firefly algorithm(fa), genetic algorithm(ga), artificial bee colony(abc). Cuckoo search algorithm is the new technique which is used in automatic generation control problems. The main advantage of CSA is its robustness. It is the most efficient method than others to achieve the optimization values.

The three units are taken hydro, thermal and gas units. The advantage of gas units is its ability to turn on and off within minutes, supplying power during peak demand. FA is used for the selection of parameters that are present in supplementary controller.

II. FOPID CONTROLLER

The fractional order Controller can be better described with the use of an equation such as Fractional order differential equations. The Riemann-Liouville is the most commonly used definition of the fractional calculous i.e.

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$${}_{\alpha}D_t^{\mu} f(t) = \frac{1}{\Gamma(m-\alpha)} \left(\frac{d}{dt}\right)^m \left(\int_{\alpha}^{t} \frac{f(\tau)}{(t-\tau)^{1-(m-\alpha)}} d\tau\right) \ldots\ldots\ldots\ldots\ldots(6)$$

In the above equation $\Gamma(m-\alpha)$ is the Euler's gamma function. Alternatively, another definition for the fractional differentiation is by the Grunwald Letnikov which is described as:

$${}_{\alpha}D_t^{a} f(t) = \lim_{k\to 0} \frac{1}{\Gamma(\alpha) h^{\alpha}} \sum_{k=0}^{(t-a)fk} \frac{\Gamma(a+k)}{\Gamma(k+1)} f(t-kh) \quad \ldots\ldots\ldots..(7)$$

After introducing the fractional order operator, the differentiator and the integrator i.e. $\alpha D_t^a f(t)$ can be combined together. Another important tool used is the Laplace transform which is the nth derivative of a signal represents such as:

$$L\{D^m x(t)\} = \int_0^{\infty} e^{-xi}\, {}_0D_t^n x(t) = S^m X(s) - \sum_{K=0}^{\infty-1} S^k\, {}_0D_t^{n-K-1} x(t)|_{t=0} \ldots\ldots\ldots\ldots(8)$$

Where x(t) is the signal relaxed at t=0. The equation 9 shows the normal Laplace transformation. Hence it has shown that fractional differential equation provides u(t) and y(t) signals relaxed at t=0. This term can be expressed as a transfer function form as:

$$G(s) = \frac{a_1 s^{\alpha 1} + a_2 s^{\alpha 2} + \cdots + a_{m_A} s^{\alpha m_A}}{b_1 s^{\beta 1} + b_2 s^{\beta 2} + \cdots + b_{m_B} s^{\beta m_B}} \ldots\ldots\ldots\ldots\ldots\ldots(9)$$

Where $(a_m, b_m) \in R^2, (\alpha_m, \beta_m) \in R_+^2, \forall (m \in N)$

Among different PID controller, the $PI^{\lambda}D^{\delta}$ is the most commonly used controller where an integrator order λ and differentiator order μ can be any real numbers. For the given PID controller, the transfer function usedis given as:

$$G_c(s) = K_P + \frac{K_1}{s^{\lambda}} + K_D s^{\mu},\ \boldsymbol{\lambda}, \mu > 0 \ldots\ldots\ldots\ldots\ldots\ldots(10)$$

The PID controller with integrator and differentiator is also considered as the Fractional Order PID controller. In this type of controller the integral (δ) and derivative (λ) can be adjusted through the user in addition to the PID constants. The values of λ and δ vary between 0 to 1.By providing these extra knobs i.e. order of differentiation and Order of integration, the level of freedom for the operator is high.

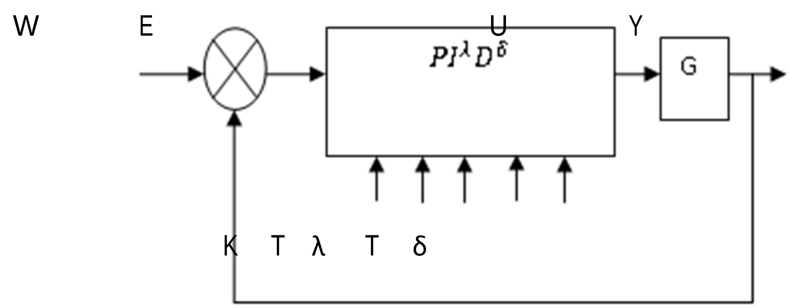

Fig 1. Fractional PID Control System

Moreover, this factor also enhances the flexibility and opportunity to the operator in order to control the system by adjusting the dynamical properties. The fractional order controller is robust but produces significant output in the presence of non-linear actuator.

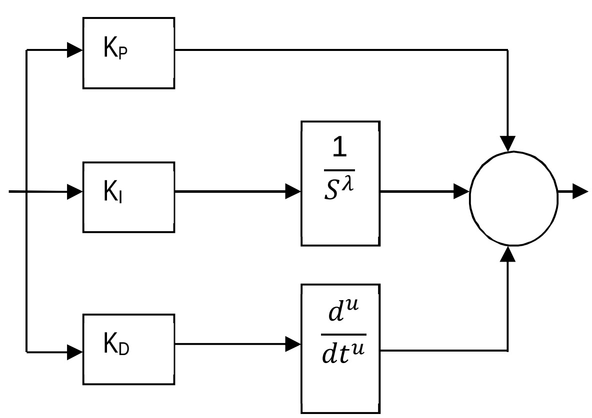

Fig 2. FOPID controller structure

Figure 3 explains the basic structure of the FOPID controller where three inputs have been forwarded to the system i.e. proportional, Integral and Derivative.

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III. RELATED WORK

Wen Tan [2010] discussed unified PID tuning method for load frequency control of power systems. This tuning has been done on the basis oftwo degree of freedom internal model design method and a PID approximation procedure. The performance of the PID controller can be judged based on the two parameters such as robustness and time domain performance which is related to the two tuning parameters. The proposed method can be applied to power systems with non-reheated, reheated and hydro turbines. Experimental analysis had performed which shows that the damping of the power system can be improved. Moreover, it had concluded that this method can also be used in multi area power systems.

H. Shayeghi et al. [2016] presented FOPID named as Fractional Order Proportional Integral Derivative controller which was optimized through Social Spider Optimization algorithm. This optimized controller was designed for load frequency control of a two area multi-source power system in the presence of Distributed Generations (DGs). The proposed controller investigated and analyzed on a two case studies. The results acquired through this analysis showed the solution of LFC task put good effect of DGs. Moreover, it enhanced the performance of the system with respect to different operating conditions and system's nonlinearities were also considered.

SanjoyDebbarma et al. [2016] described different applications and design of Two Degree-of-Freedom-Fractional order PID controller which is used to resolve the problem of Automatic Generation Control in hydrothermal system and in multi area system. These systems consist of different units such as hydro, thermal and gas units. AGC is recommended for each particular unit. The performance of proposed and conventional controllers was compared with each other for both the systems. A Cuckoo Search Algorithm had used to acquire optimal parameters of the respective controllers. Experiments were performed and it has been concluded that proposed 2 DOF-FOPID controller outperforms in comparison with conventional controllers. The proposed controller had significant reduction in peak overshoots as well as oscillations and improvement in setting time. In addition to that, proposed controller was more robust when examined through sensitivity analysis.

Veena Sharma et al. [2016] presented the solution regarding a problem of Automatic Generation Control of four area interconnected power system which included the DFIG i.e. Doubly Fed induction generator wind turbine. This turbine used Gravitational Search Algorithm for the tuning of gains in terms of speed as well as pitch angle controller of DFIG wind turbine. The opposition based learning concept was embedded into the GSA in order to speed up its performance. This implantation in GSA was termed as Opposition Learning based GSA. The simulations performed between GSA and OGSA confirmed that the OGSA was more effective in terms of setting time, faster convergence, overshoot as well as undershoot of the deviations in frequency and tie-line power. The competency of the proposed controller ensured through the variations of the wind penetration from 10% to 40%.Apart from this the performance of the proposed technique was also measured in the control area from 0.1 p.u MW to the 0.4 p.u MW for large load perturbation.

IV. CUCKOO SEARCH ALGORITHM

It is a meta heuristic approach introduced by X.S. Yang whichj deals with the optimization problems. Each egg is considered as the solution and the solution is based on the population. A population of "n" host nests is represented by x = (x1, ..,xd)T, and the initial solutions is determined by

$$x_i = L_{xi} + rand_1(U_{xi} - L_{xi})\ldots\ldots\ldots\ldots\ldots\ldots\ldots(14)$$

Where $L_{xi} and U_{xi}$ are the lower and upper bounds for each decision variable, xi is d-dimension solution vector and rand 1 is a uniformly distributed random number in [0,1] for each population of the host nests. The parameters of controller are mapped bird's nest which is to be optimized using CSA by minimizing the performance index (J).

New solution is determined based on previous best nests via Lévy flights and can be given as follows:

$$x_i^{new} = xbest_i + \alpha \times rand_2 \times \Delta x_i^{new}\ldots\ldots\ldots\ldots..(15)$$

Where α> 0 is the step size scaling factor, $rand_2$ is a normally distributed stochastic number. The increased in the value of Δx_1^{new} is calculated by

$$x_i^{new} = v\ x\ \frac{\gamma_x(\beta)}{\gamma_y(\beta)} x(xbest - Gbest)\ldots\ldots\ldots\ldots\ldots.(16)$$

where the step length v can be calculated by the following equation

$$v = \frac{rand_x}{|rand_y|^{1/\beta}}\ldots\ldots\ldots\ldots\ldots\ldots\ldots(17)$$

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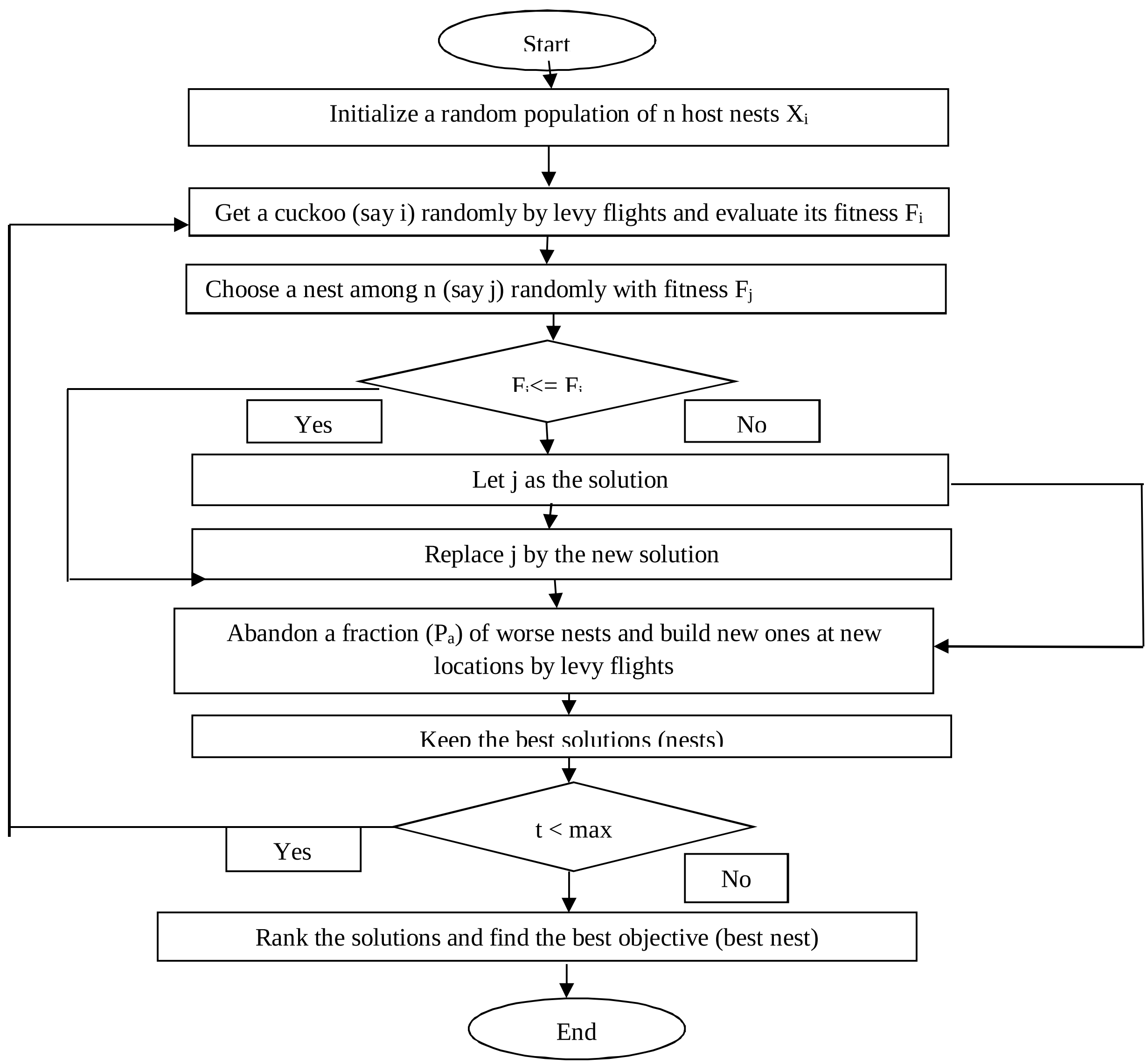
V. CUCKOO SEARCH ALGORITHM

1) Objective function f(x), x= ($x_{1,........}x_d$)
2) Generate initial population of n host nest x_i (i=1,2,..n)
3) While (t< MaxGeneration) or (stop criterion)
4) Get a cuckoo randomaly by L evy flights
5) Evaluate the quality fitness
6) Choose a nest among n(say, j) randomly
7) If (F_i>F_j)
8) Replace j by the new solution
9) end
10) A fraction (p_2) of worse nest
11) Are abandonded and new ones are built
12) Keep the best solutions (or nests with quality solutions)
13) Ran the solutions an find thcurrent bst
14) End while
15) Potprocess results an visulization

VI. FLOW CHART



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VII. EXPERIMENTAL RESULTS

The three units hydro, gas, thermal are controlled differently. The cuckoo search algorithm is applied differently on every unit.

A. Electric Governor PID Controller

Initially the experiments have performed on the electric governor PID controller using the traditional Cuckoo search and Firefly optimization algorithm. The acquired results have shown below:

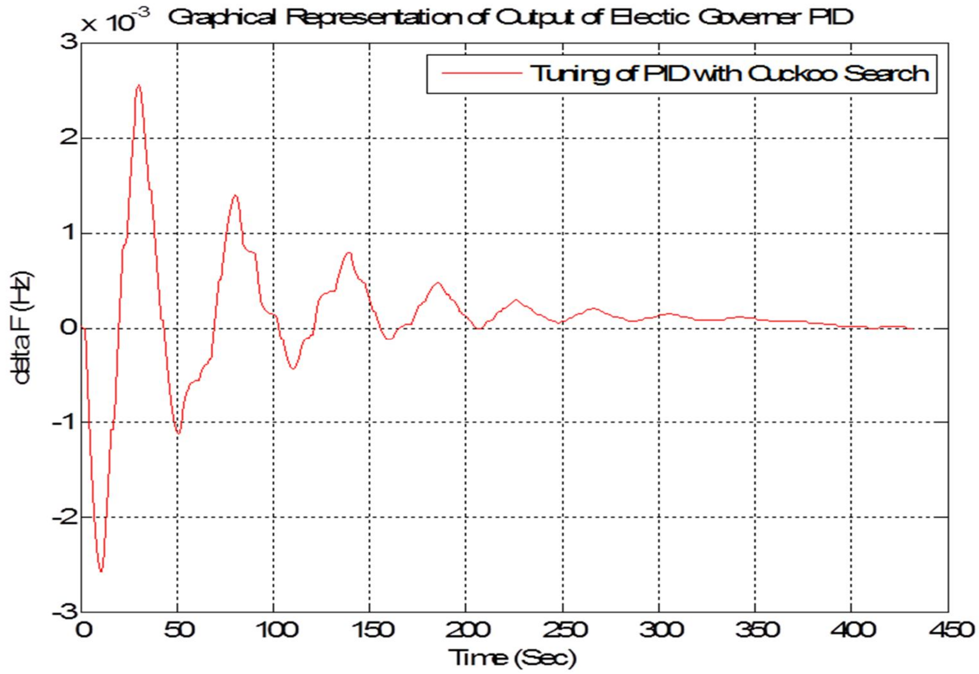


Fig 3. Output of the electric governor PID controller by using Cuckoo Search Algorithm

B. Hydrothermal PID Controller

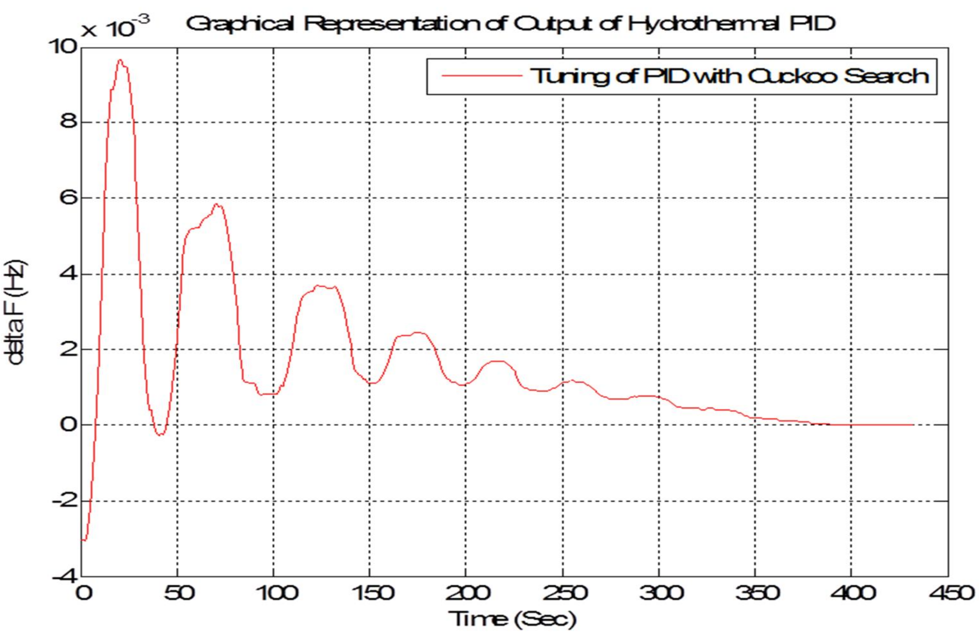


Fig 4. Output of the Hydrothermal PID controller by using Cuckoo Search Algorithm

C. Gasthermal PID Controller

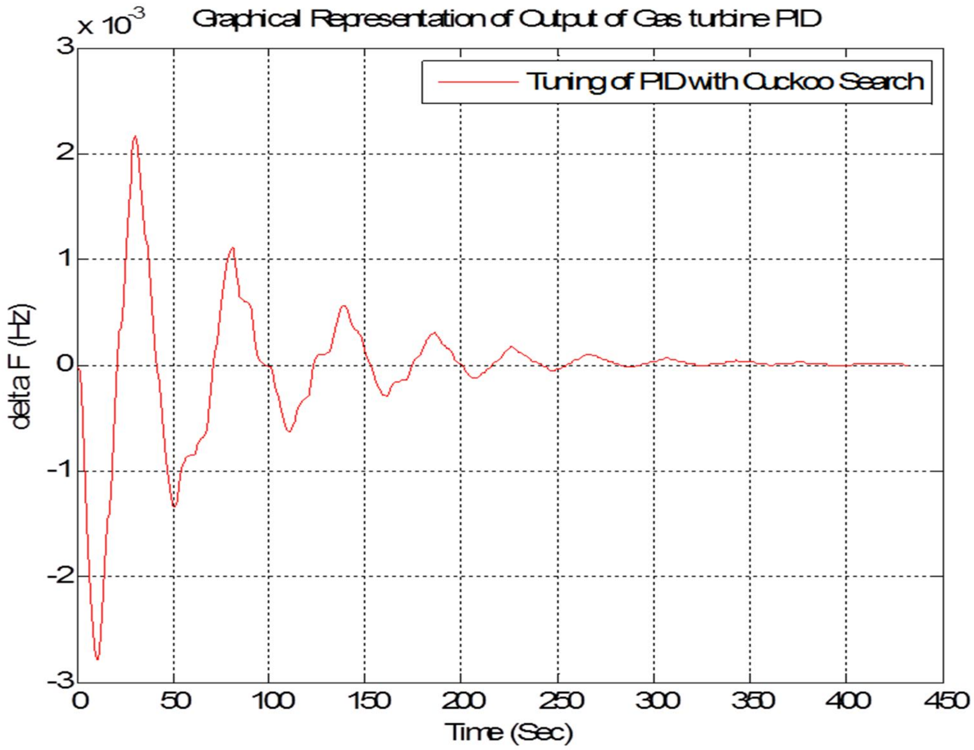


Fig 5. Output of the Gas Turbine PID controller by using Cuckoo Search Algorithm

V. CONCLUSION

This study develops a Cuckoo search algorithm based PID controller for the output of three power grid systems. The simulation is done by considering the output of three power systems such as hydrothermal power system, gas turbine and electric governor power system. The proposed system presents a tuning of PID controller with cuckoo search algorithm.

REFERENCES

[1] Abdul-ghaffar I.H.,Ebrahim. A. E. and Azzam A., "Design of PID Controller for Power System Stabilization Using Hybrid Particle Swarm-Bacteria Foraging Optimization" WSEAS transactions on power systems, Issue 1, Volume 8, Pp 12-23, ,January 2013.

[2] Arzani Ali, Arunagirinathan Paranietharan, Jayawardene, Iroshani and Venayagamoorthy, K.Ganesh,"Dynamic Performance Enhancement of a Utility-Scale Solar PV Plant", IEEE, pp. 26 – 30, 2016.

[3] Bevrani Hassan,Daneshfar Fatemeh and HiyamaTakashi, "A New Intelligent Agent-Based AGC Design With Real-Time Application", IEEE, vol. 42, pp. 994 – 1002, 2012.

[4] DebbarmaSanjoySaikia ChandraLalit, SinhaNidul, Kar Biswajit andDattaAsim, "Fractional order two degree of freedom control for AGC of an interconnected multi-source power system", IEEE, pp.505–510, 2016.

[5] Debnath Kumar Manoj,Singh Bahadur Manjit and Mallick KumarRanjan, "Design of Optimal 2-DOF PID controller using GWO Technique for Automatic Generation control of a multisource Power System", IEEE, pp. 531 – 536, 2016.

[6] El-Metwall A.Khaled, "Power system stabilization using swarm tuned fuzzy controller" Proceedings of the 17th World Congress The International Federation of Automatic Control Seoul, Korea, July 6-11,Pp 11106-11111, 2008.

[7] Guolian HOU,ZhengXiaobin, Jiang Pengcheng and Zhang Jianhua, "Study of Modeling and Intelligent Control on AGC System with Wind Power", IEEE, pp. 4775 – 4780, 2014.

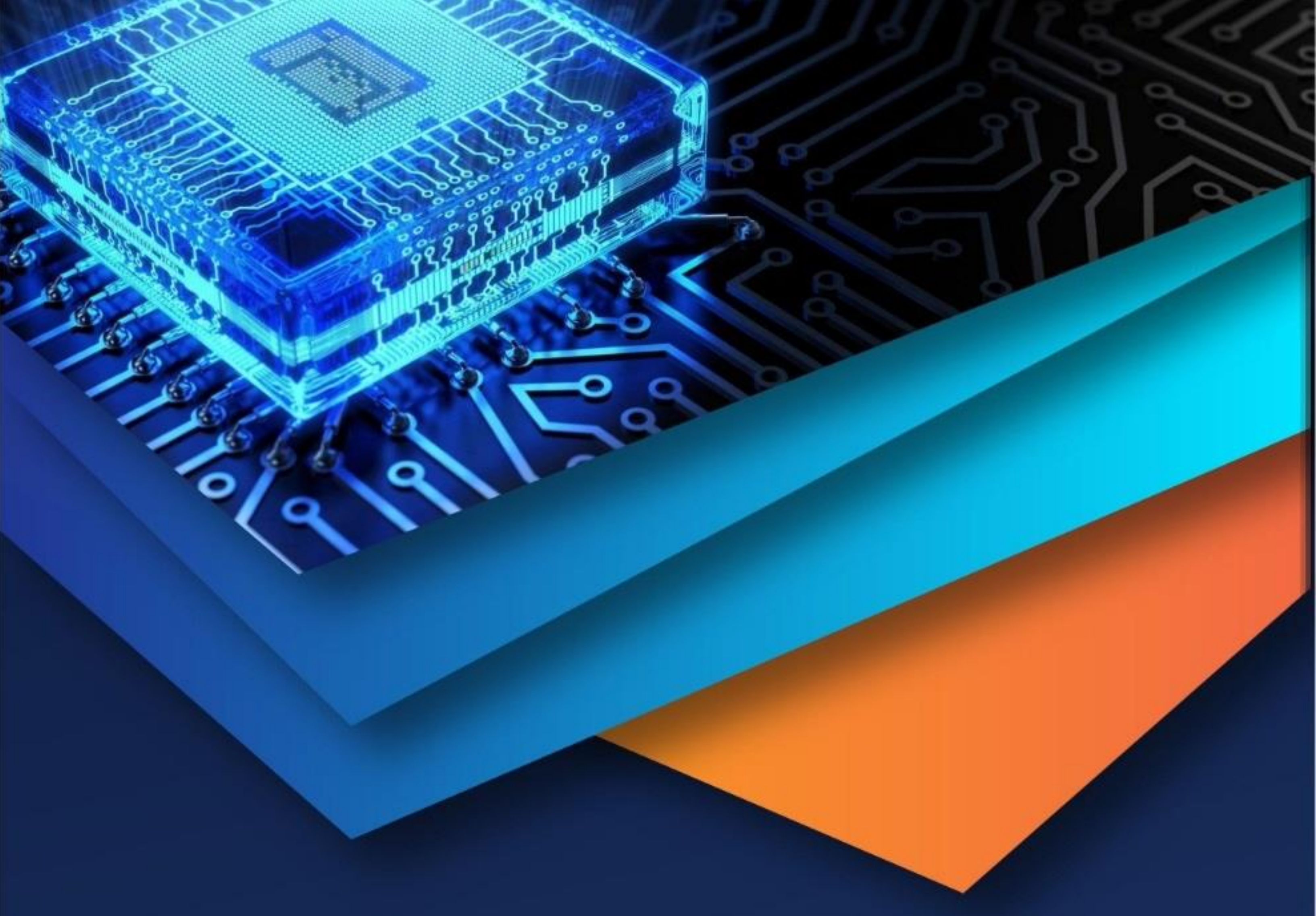
[8] Hiyama Takashi, Zuo Dunding and Funabashi T., "Multi-Agent Based Automatic Generation Control of Isolated Stand Alone Power System", IEEE, vol. 1, pp. 139 – 143, 2002.

[9] Karray F.,Gueaieb W. and Sharhan Al-S., "The Hierarchical Expert Tuning of PID Controllers Using Tools of Soft Computing" IEEE , Vol. 32, no.Pp 77 -87., February 2002 .

[10] Kawanishi Tetsuya,Inagaki Keizo, Kanno Atsushi and YamamotoNaokatsu, "Precise Measurement Techniques for Optical-to-electric Conversion", IEEE, pp. 3906 – 3906, 2016.

[11] Li Yuxiang, Zhao Yinliang and Shi Jiaqiang, "A Hybrid Samples Generation Approach in Speculative Multithreading", IEEE, pp. 35 – 41, 2016.

[12] Li Zhongwen, Zang Chuanzhi, Zeng Peng, Yu Haibin and Jing Bian, "Fully Distributed Optimal Automatic Generation Control for an Islanded Microgrids", IEEE, pp. 13 – 17, 2016.



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