International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 07 | July -2017 www.irjet.net p-ISSN: 2395-0072

Load Frequency Control of Single Area Power System Using JAYA Algorithm

Vikas Singh[1], Alok Kumar Singh[2], Vibhor Chauhan[3], Dr. Alok Kumar Bharadwaj[4]

[1]M.Tech. Scholar, Jaipur Institute of Technology, Jaipur, Rajasthan
[2,3] Associate Professor, Jaipur Institute of Technology, Jaipur, Rajasthan
[4] Professor, Bengal College of Engineering and Technology, Durgapur

---

Abstract - *The constant frequency with reliability of power is a frame set to drive the enormous industrial and other loads in the power systems of modern time. As per unremitting development of size and complexity of electrical power system with growing interconnections, the problem to maintain the power and frequency free from oscillations has become increasingly severe because of irregular load variations. These undetermined load fluctuations result in mismatch of generated power and load demand for consumption, which finally distresses the quality and reliability of electric power supply. This can be achieved by the load frequency control (LFC) methods. Now a days lot of work is going on to make the systems intelligent so the systems can smartly serve for the betterment of mankind. Even the power sector is also being benefitted by that which is being done by the help of soft computing techniques. This study is an effort in the same direction in which we implemented the JAYA algorithm along with PID controllers to improve the frequency response of single area power system.*

Key Words: frequency control, PID controller, transients, controller parameters, JAYA technique

1. INTRODUCTION

The LFC has crucial role in large size electric power systems with complex interconnections between the areas it has. The main goal of operation of the LFC is to sustain the frequency within the limits of every area in the power system and to keep tie-line power flows within some given or decided limit which is achieved by amending the wattage outputs of the generating alternators to match the inconsistent load demands. In the past few years enormous improvement has been made in the area of load frequency control in interconnected system of power transfer. Designing the LFC with the help of PID controllers makes it prominent and trustworthy, but the main challenge is to decide the parameters of PID controllers.

1.1 PID CONTROLLERS

It is well known fact that a proportional integral derivative controller (PID controller) is a standard close loop controller without which the process control in the industries will become a hard nut to crack. A PID controller basically initiates an action to remove the error between output and reference point, consequently and swiftly, to keep the error trivial within endurable limit. It is an encapsulate unit of proportional, integral and derivative control mode. As it has non-complex structure while it is delivering robust performance is the major reason that it why it is widely used in global applications. The PID controller constraints are set such that closed loop system performance encounters the required specifications and over an extensive range of change input or change in system parameters due to stray effects gives the stout performance and keep the output within required perimeter. Practically, it is almost impossible to have such controller which offers the output with required level and shape of waveform under every internal or external disorder.

1.2 Parameters of PID Controllers

The designing of PID controller actually deals with the scheming of its parameters; i.e. the proportional, integral & derivative coefficient. The process control industries are mostly backing by the PID controller usage in its control strategies.

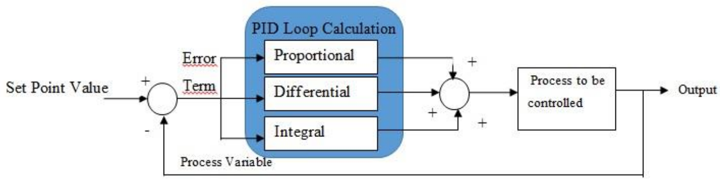

Fig -1: PID controller in closed loop system

Let,
K_{prop} = Proportional Gain
K_{inti} = Integral Gain
K_{deriv} = Derivative Gain

Then the output of proportional, integral and derivative control mode is given by (K_{prop} X Error), (K_{inti} X $\int$Error.dt) and (K_{deriv} X d/dt(Error))respectively. It shows that the magnitude of action of proportional controller is depends on recent error, the reaction of the integral constant depends on the sum of recent errors, and the reaction of derivative constant is based on the rate at which the errors have been changing. Finally the process is controlled by the pooled actions of all three. In simple manner, Proportional mode depends on the current going error, Integral mode depends on the sum of errors of past, and Derivative mode depends on the errors of future based on current rate of change of errors. In a closed loop system (CLS) the variation in the gain parameters shows relevant variations in the characteristics which can be clearly understand by the following observations.

Table -1: Effect on Close loop System Characteristics Due to Gain Parameters of PID Controllers

Controller Parameters	Effect on Rise time	Effect on Steady-state error	Effect on Overshoot	Effect on Settling time
K_{Prop}	↓	↓	↑	Small Variation
K_{Inti}	↓	Removed	↑	↑
K_{Deriv}	Small Variation	No Variation	↓	↓

2. TUNING METHODS of PID

The main thing is to be done in the closed loop system with PID controller is to elect the mathematical values of Proportional, Integral and Derivative deciding parameters known as tuning of controller. There are many tuning methods are available to the PID controllers like manual tuning which requires experienced workforce, Ziegler-Nichols method which is said to an aggressive method and online tuning process, Cohen-coon method which is an offline method and only first order process can be determined nicely by it etc., In these methods it is very urgent to get exact transfer function of the system only than it is possible to practice the traditional methods for tuning the PID controller. But in real-world it is very challenging to attain the exact process controlling using traditional tuning methods to tune the PID controllers due to the persistence of high ambiguity in the modelling of practical systems. A precise type of mathematical model is required like first order plus dead time for tuning the process model by traditional methods. Soft computing methods can be the good solution for the problem of precise tuning as these techniques has superiority in solving the complicated and lengthy calculations and even those problems that are mathematically untrack able. The few examples of soft computing methods are Neural Network, Fuzzy Logic, Particle Swarm Optimization etc., But recent JAYA optimization methods has some aids over others. To understand it

3. JAYA TECHNIQUE

The most advantageous thing about this algorithm is its ease of implementation as there is no algorithm-specific variable which are required to be set on which the success of algorithms to converge will depend. The algorithm by itself move closer to best solution avoid failure by avoiding the worst solutions. The algorithm endeavors to become victorious by achieving the best solution and hence it is named as Jaya (a Sanskrit word meaning victory).

To implement and understand JAYA Algorithm following variable terms has to be taken:
f(x) = our objective function which is to be minimized or maximized.
i = number of iteration going on
m = number of design variables assumed (i.e. j=1,2,...,m)
n = number of candidate solutions (k=1,2,...,n).

At i_{th} iteration if the best candidate gives the most optimal value of f(x) i.e. meet our requirement among all the candidate solutions and for the worst candidate we get the worst value of f(x) means it is at farthest from required optimal solution among all the candidate solutions. Now any jth variable whose value at kth iteration is Lj,k,i, is modified according to following equation.
$L'_{j,k,i} = L_{j,k,i} + y_{1\,j,k,i}\,(L_{j,best,i} - |L_{j,k,i}|) - y_{2\,j,k,i}\,(L_{j,worst,i} - |L_{j,k,i}|)$
Here
$L_{j,best,i}$ = j th variable corresponding to best solution
$L_{j,worst\,,i}$ = j th variable corresponding to worst solution
$L'_{j,k,i}$ = modified value of $L_{j,k,i}$
$y_{1\,j,k,i}$ & $y_{2\,j,k,i}$ = random numbers during i th iteration for the *j* th variable in between [0, 1]
"$y_{1\,j,k,i}\,(L_{j,best,i} - |L_{j,k,i}|)$" is the term which makes the solution to get closer and closer to optimal solution and the term "$- y_{2\,j,k,i}\,(L_{j,worst,i} - |L_{j,k,i}|)$" makes the solution to get to sidestep the worst solution. Finally $L'_{j,k,i}$ will be accepted as our required optimal solution when it gives better function value. At the end of iteration all accepted optimal values will be retained and will serve as input to the next iteration.

3.1 Workflow in "JAYA" Algorithm

Soft computing methods can be the good solution for the problem of precise tuning of PID controllers as these techniques has superiority in solving the complicated and lengthy calculations and even those problems that are mathematically untrack able. This is possible only because of the inherit capability of soft computing techniques to combine the physical system with fastest calculating processing unit to make the system utmost possible stable. Jaya Optimization method has some aids over other available soft computing technique that is why we are implementing it to decide the tuning parameters of PID controller. The procedure is as follows:

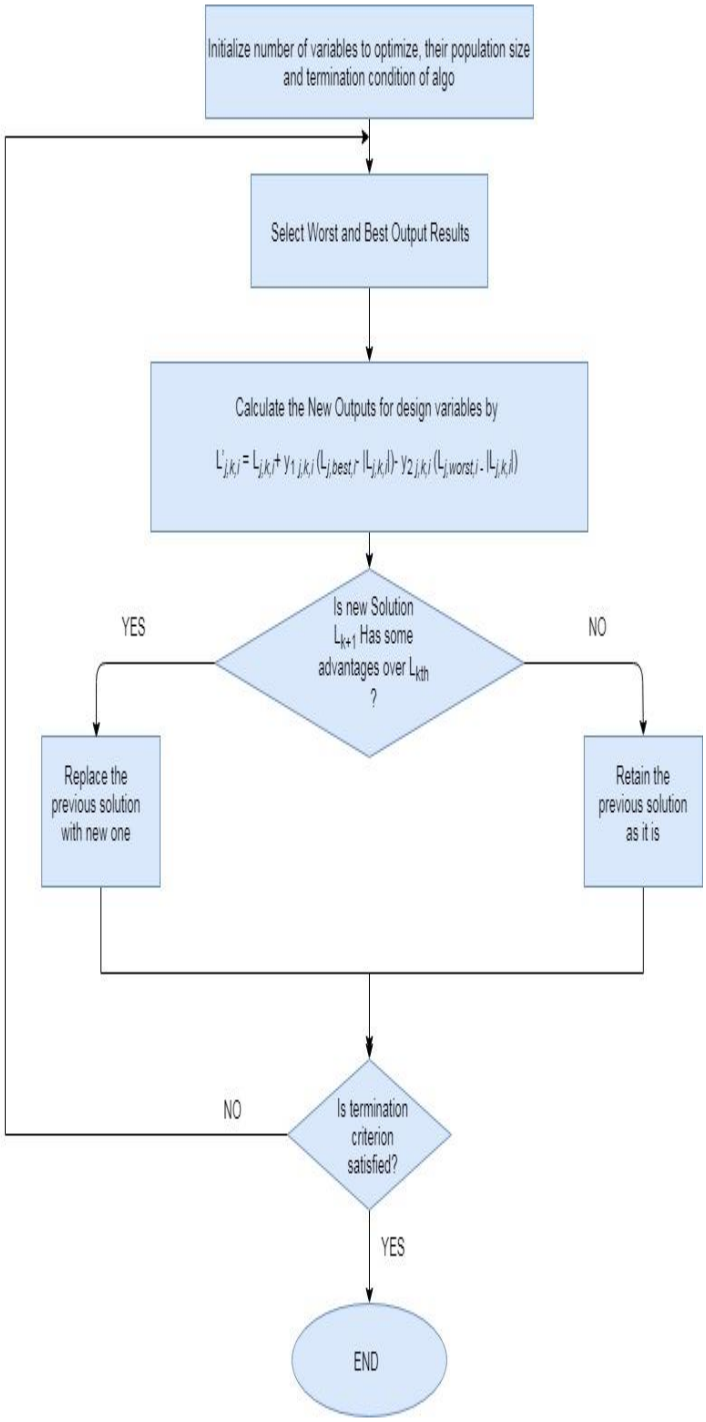

Fig -2: Flow chart of JAYA Algorithm to determine tuning parameters for PID controllers

4. SYSTEM SIMULATION & RESULT ANALYSIS

In this the effectiveness of JAYA optimization technique has been scrutinized by applying it in power system for the problems in load frequency control. To accomplish this anticipated method has been applied to determine the controller parameters for load frequency controllability of single area power system. The purpose of load frequency control is to preserve the balance of real power demand and generation in the system at acceptable nominal frequency by control of system frequency. Whenever there is a change in load demand its results in the change in speed of alternator finally led to change in system frequency. The deviation in nominal frequency is amplified and mixed. Finally a proportional command signal is generated which controls the mechanical input to turbine through governor. The governor deeds such that to reestablish the equilibrium between the generation and demand by maintaining the turbine output. The system parameters for the study are tabulated further.

Table -2: System parameters taken for study

S. No.	Description	Symbol	Value
1	Inertia constant	H	10
2	Load constant	D	0.8
3	Governor time constant	τ_g	0.2
4	Turbine time constant	τ_t	0.5
5	Droop coefficient	R	0.01

Using these values of various parameters we produced a Matlab Simulink Model of isolated load frequency control has been developed which is shown below in figure

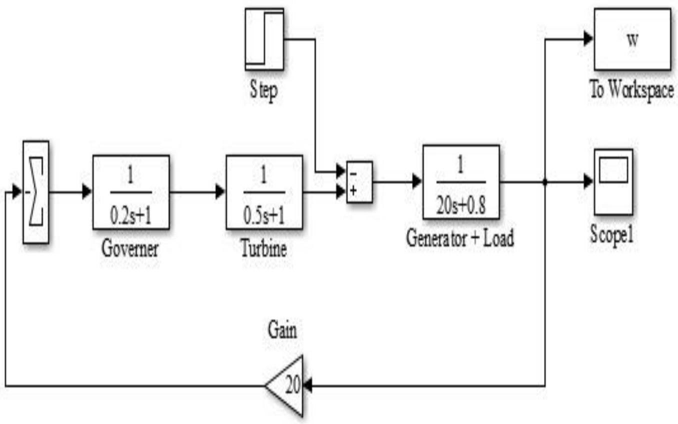

Fig -3: Simulink Model of Isolated Non-reheat Type Power System.

Figure shows that the deviation in frequency of system for a step load change of 0.2 pu deprived of secondary loop control. After change in load and settles to 0.19 pu MW without control while settled at new reduced frequency by - 0.01 Hz.

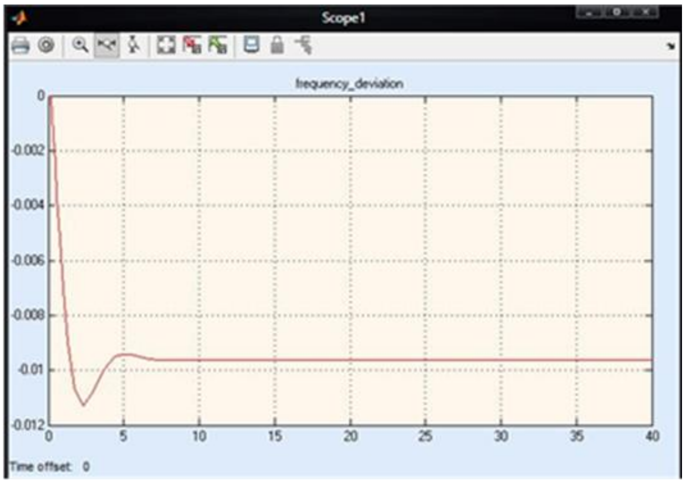

Fig -4: Step Response of generator load frequency without secondary control loop

From the step response graphical representation (figure 4) of the system frequency it is clear that there is inherent steady state error in load frequency response of system for a step input.

There is urgent need of stable feedback control which could reduce the frequency error to zero after a load change. So now to the previous shown isolated system along with PID controller in which parameters are decides by applying JAYA optimization technique and the value of K_{inte} = 278 and K_{prop} = 130 and K_{deriv} = 381 are obtained. Using these values the new Matlab Simulink Model has been developed shown in the figure below.

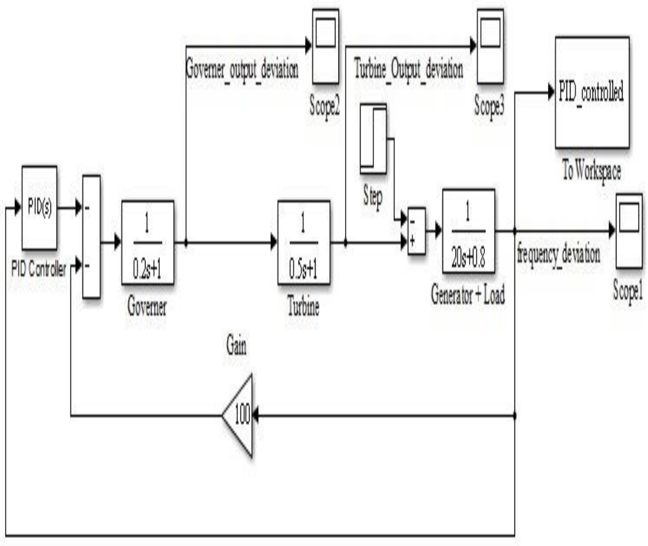

Fig -5: Simulink Model of Isolated Non-reheat Type Power System with JAYA based secondary PID controller

Above shown single area system has been provided with a PID controller for purpose of controlling the deviation of system frequency. The frequency response of system for a 20% load change controlled with JAYA based PID controller has been shown in figure

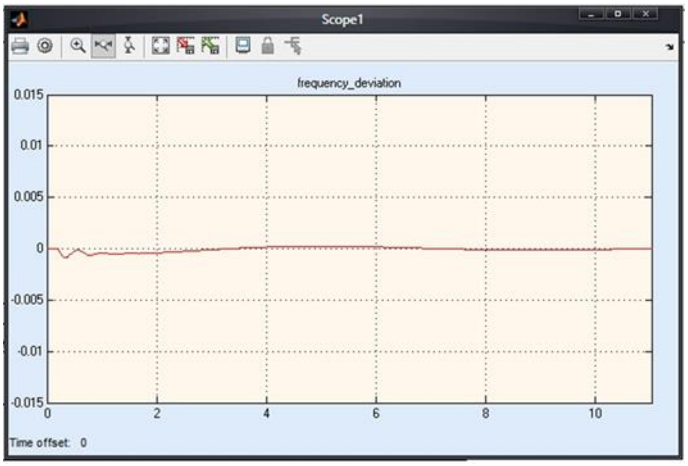

Fig -6: Step Response of generator load frequency with JAYA based PID secondary control loop

Dynamic response of the system has been compared in table below for 20% step load change for with and without load frequency controller.

Table -3: Comparison of Dynamic Responses

	without Controller	**with PID Controller**
Steady state error	0.012pu	0
% reduction in Steady state error		100 %
Peak overshoot	-0.0048	-0.0009
% reduction in peak overshoot		81.25 %
Settling time	6 Sec	3 Sec
% reduction in settling time		50 %

5. CONCLUSIONS

As we implemented Jaya optimization Technique for designing the PID controller for the load frequency control of non-reheat type single area power system. The PID controller based on JAYA technique has given a much improved transient and steady state response for frequency deviation. The simulation results are also proving the same. The results obtained with this technique are promising. Therefore, with the Jaya optimization technique based PID controllers are capable to generate reliable and better quality electric power.

REFERENCES

[1] Armin Ebrahimi Milani and Babak Mozafari, "Genetic Algorithm Based Optimal Load Frequency Control In Two-Area Interconected Power Systems", Global Journal of Technology and Optimization, pp. 6 – 10, Vol. 2, January 2010.

[2] A.Soundarrajan, Dr.S.Sumathi and C.Sundar, "Particle Swarm Optimization Based LFC and AVR of Autonomous Power Generating System", IAENG International Journal of Computer Science, pp. 37 – 44, Vol. 1, February 2010.

[3] Babak Keyvani Boroujeni, "Two-Area Load Frequency Control Using IP Controller Tuned Based on Tabu Search", Journal of Basic and Applied Scientific Research, 1(12)2817-2822, 2011.

[4] Ndubisi Samuel .N., "A single area load frequency control: a comparative study based on pi, optimal and fuzzy logic controllers", American Journal Of Scientific And Industrial Research, pp. 748-754, Vol. - 2(5), 2011.

[5] Surya Prakash and S.K. Sinha, "Load frequency control of three area interconnected hydro-thermal reheat power system using artificial intelligence and PI controllers", International Journal of Engineering, Science and Technology, pp. 23-37, Vol. 4, No. 1, 2011.

[6] Mohamed. M .Ismail and M. A. Mustafa Hassan, "Load Frequency Control Adaptation Using Artificial Intelligent Techniques for One and Two Different Areas Power System", International Journal of Control, Automation And Systems, pp. 12 – 23, Vol. 1, No. 1, January 2012.

[7] Isha Garg and Mohd. Ilyas, "Study of Two Area Load Frequency Control in Deregulated Power System", International Journal of Innovative Technology and Exploring Engineering (IJITEE) pp. 42 – 45, ISSN: 2278-3075, Volume-1, Issue-2, July 2012.

[8] V. Ganesh, K.Vasu and P.Bhavana, "LQR Based Load Frequency Controller for Two Area Power System", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 1, Issue 4, October 2012.

[9] G.Karthikeyan, S.Ramya And Dr. S.Chandrasekar, "Load Frequency Control For Three Area System With Time Delays Using Fuzzy Logic Controller", International Journal Of Engineering Science & Advanced Technology, Pp. 612 – 618, Volume-2, Issue-3, May-Jun 2012.

[10] Sachin Khajuria and Jaspreet Kaur, "Load Frequency Control of Interconnected Hydro-Thermal Power System Using Fuzzy and Conventional PI Controller", International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), pp. 65 – 72, Volume 1, Issue 8, October 2012.

[11] Ashok Mohan Jadhav, K. Vadirajacharya and Elijah Tintius Toppo, "Application Of Particle Swarm Optimisation In Load Frequency Control Of Interconnected Thermal-Hydro Power Systems", Int. J. Swarm Intelligence, pp. 91 – 113, Vol. 1, No. 1, 2013.

[12] Atul Ikhe and Anant Kulkarni, "Load frequency control for interconnected power system using different controllers", Automation, Control and Intelligent Systems, Science Publishing Group, pp. 85-89, Vol. 1, No. 4, 2013.

[13] Prathibha M and Bhavani M, "Automatic Generation Control in Restructured Power System with Wind Integrated System", International Journal of Innovative Research in Science, Engineering and Technology, pp. 461 – 467, Volume 3, Special Issue 3, March 2014.

[14] R.V. Rao, V.J. Savsani, D.P. Vakharia, "Teaching-learning-based optimization: a novel optimization method for continuous non-linear large scale problems", Inform. Sci. 183 (2012)1–15.

[15] R. Venkata Rao, "Jaya: A simple and new optimization algorithm for solving constrained and unconstrained optimization problems", International Journal of Industrial Engineering Computations, pp. 19 – 34, Vol.-7, 2016.