Optimization of Controller Values of Interconnected Power System

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Abstract: - **This research paper presents decentralized control scheme for Load Frequency Control in a multi-area Power System by appreciating the performance of the methods in a single area power system. A number of modern control techniques as well as the classical methods and optimization algorithm are adopted to implement a reliable stabilizing controller. A serious attempt has been undertaken aiming at investigating the load frequency control problem in a power system consisting of two power generation unit and multiple variable load units. The robustness and reliability of the various control schemes is examined through simulations and Mat-Lab programming. The design is determined an optimization problem and a novel cost function is derived for increasing the performance of convergence to the solution. To optimize the parameters of the cost functions and the PID-controller, the Ziegler-Nichols method of PID tuning also used here. The results show that the proposed control method is provided better performance for dynamic responses of the power system.**

Keywords: Load frequency control, Transient response, single area power system, PSO Algorithm, Ziegler-Nichols method

I. INTRODUCTION

The active power and frequency control is referred to as load frequency control (LFC) .The foremost task of LFC is to keep the frequency constant against the randomly varying active power loads, which are also referred to as unknown external disturbance. Another task of the LFC is to regulate the tie-line power exchange error. A typical large-scale power system is composed of several areas of generating units. In order to enhance the fault tolerance of the entire power system, these entire units are connected via tie-lines. The usage of tie-line power imports a new error into the control problem, i.e., tie-line power exchange error. When a sudden active power load change occurs to an area, the area will obtain energy via tie-lines from other areas. But eventually, the area that is subject to the load change should balance it without external support. In order to satisfy the change in load demand, by keeping the frequency deviation error within a tolerance level PID controllers are needed. These PID controller values can be optimized by using different optimization technique. In this work we have used the particle swarm optimization technique (PSO) and Ziegler-Nichols tuning method for the optimization of PID controller values. Integral square error method is used as the performance index for PSO algorithm. Our objective function is to minimize the fitness function value.

II. DYNAMICS OF THE POWER GENERATING SYSTEM

2.1 Single Area Power System

Most of the reported solutions of the LFC problem have been tested for their robustness against large step load change. However, very few of the published researches deal with parameter uncertainties. The simplified system model has deviated far from the real system. A control technique with a notable robustness against not only parameter uncertainties but also model uncertainties and external load change will be preferred by the power industry.

2.2 Mathematical Modeling of Hydro Power Plant Component

Hydraulic turbine Transfer Function
The hydraulic turbine and penstock characteristics are determined by three parameters

1.1 Velocity of water in the pen stock
2.1 Turbine mechanical power
3.1 Acceleration of water columns

Dividing Δ_{pm} by Δ_G

$$\frac{\Delta_{pm}}{\Delta_G} = \frac{1-sT_w}{1+.5sT_w} \quad (1)$$

Where, Δ_{pm} = Development of mechanical power due to small change in gate position.
Δ_G= small change in gate position Transfer function of hydraulic turbine.

2.3 Hydraulic Governor Modeling

Governors are the units that are used in power systems to sense the frequency bias caused by the load change and cancel it by varying the inputs of the turbines.

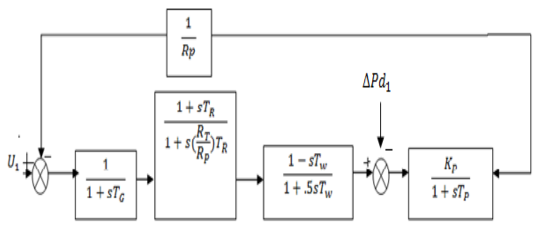

Fig.1 Block Diagram of Hydro power plant with transient droop characteristic

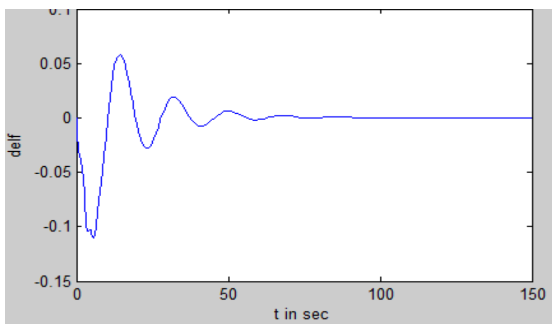

Fig2.Output of single area hydro power plant

2.4 Load Frequency Control of Two Area Interconnected Hydro Power Plant

An extended power system can be divided into a group of load frequency Control areas inter connected by means of tie Line.

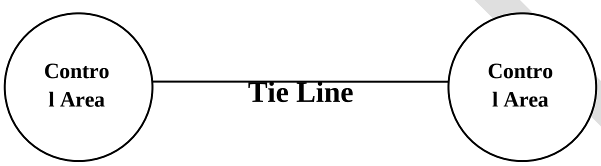

Fig.3 Two inter Connected Control areas (Single Tie Line)

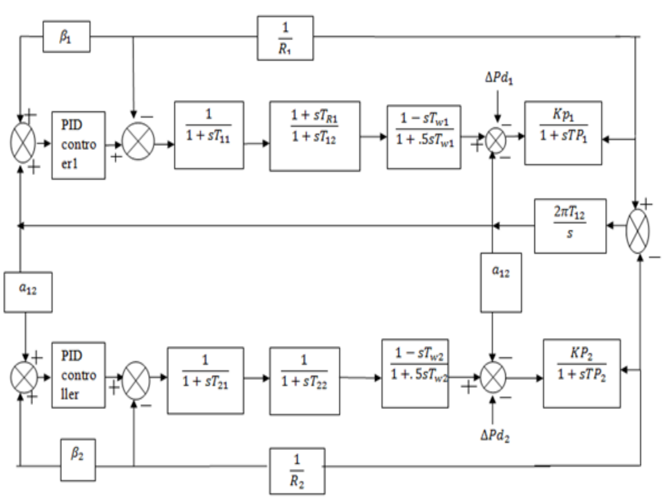

Fig4.Block diagram of two area interconnected power station

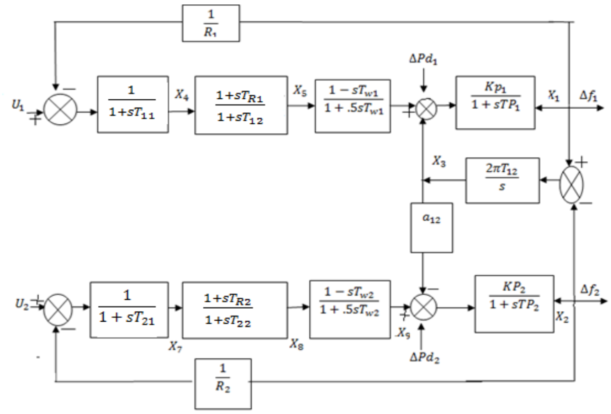

Fig.5 Block diagram of two area interconnected hydro power station without controller

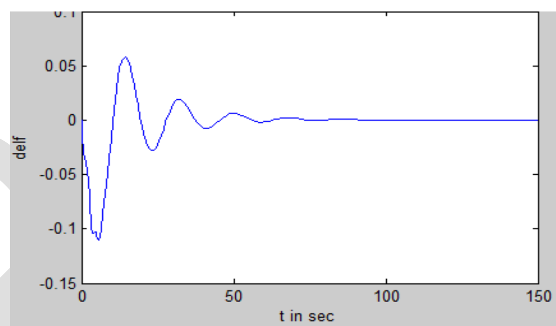

Fig6. (a) Output of area 1 of two area hydro power plant

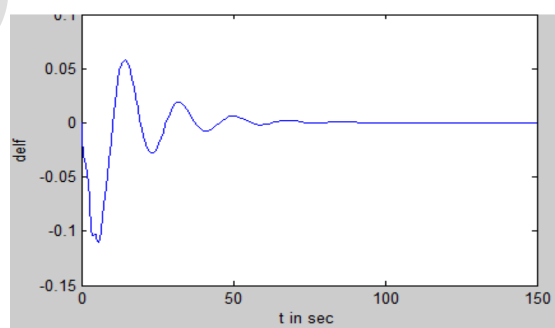

Fig6. (b) Output of area 2 of hydro power plant

III. Ziegler-Nicholas METHOD FOR UNING OF PID CONTROLLER

If a mathematical model of a plant is given, then it is possible to apply different design technique for determining parameters of the controllers that will meet the transient and steady state specifications of the closed loop system. However if the plant is so complicated that its mathematical model can't be easily obtained, then an analytical or computational approach to the design of a PID controller is not possible.

TABLE I

Controller type	Kp	Ki	Kd
P controller	.5Kpu	∞	0
PI controller	.45Kpu	.5Pu	0
PID controller	.0Ku	.5Pu	.125Pu

For our two area power system model we got the sustained oscillation at K_p=.05The critical frequency as well as the critical gain of the system can also be find out by finding the root locus of the closed loop system, the point at which the root locus cross the imaginary axis is known the critical frequency. At that corresponding frequency the critical gain is find out.

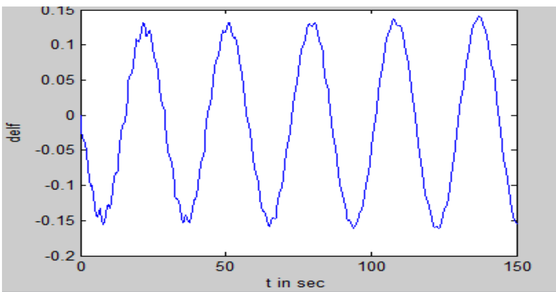

Fig.7 sustained oscillation for Ziegler –Nicholas method

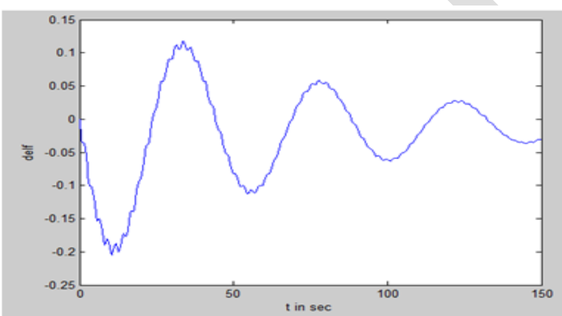

Fig.8(a).output of interconnected hydro power plant of area 1

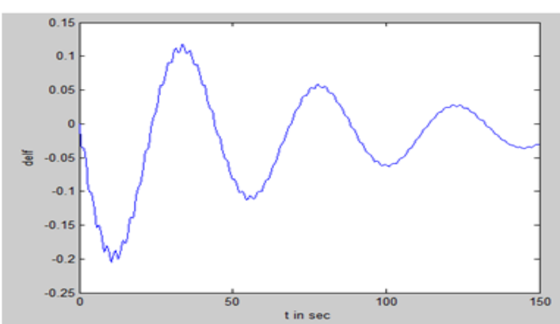

Fig.8 (b).output of interconnected hydro power plant of area 2

IV. PARTICLE SWARM OPMIZATION (PSO)

PSO is a stochastic Evolutionary Computation technique based on the movement and intelligence of swarms. The original PSO algorithm is discovered through simplified social model simulation.

4.1 Optimization of PID values by PSO algorithm of hydro-thermal Power plant

In D-dimensional search space, the position of the *i*th particle can be represented by a D-dimensional vec tor, $X_i = (X_{i1}\ldots X_{id}\ldots XiD)$. the velocity of the particle v_i can be represented by another D-dimensional vector $V_i = (V_{i1}\ldots V_{id}\ldots V_{iD})$. The best position visited by the *i*th particle is denoted as $P_i=(P_{i1},\ldots,P_{id},\ldots,P_{iD})$, and Pg as the index of the particle visited the best position in the swarm, then Pg becomes the best solution found so far, and the velocity of the particle and its new position

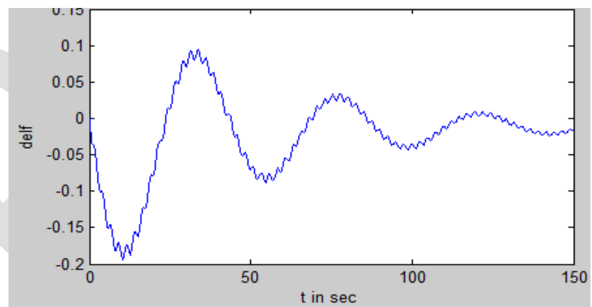

Fig9. (a) Output of two area hydro power plant for area 1

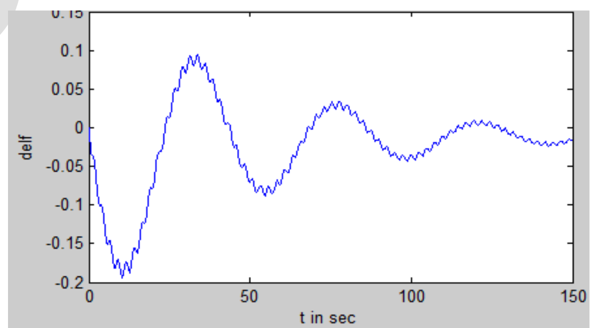

Fig9. (b) Output of two area hydro power plant of a area 2

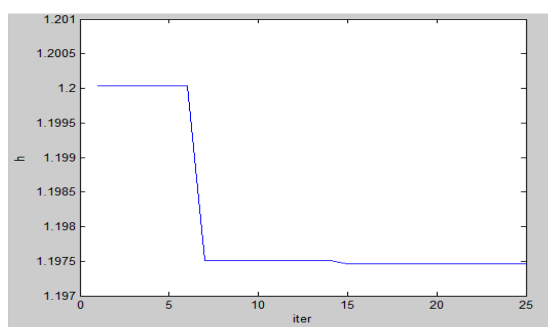

Fig10.Generation vs. iteration of inter connected hydro power plant

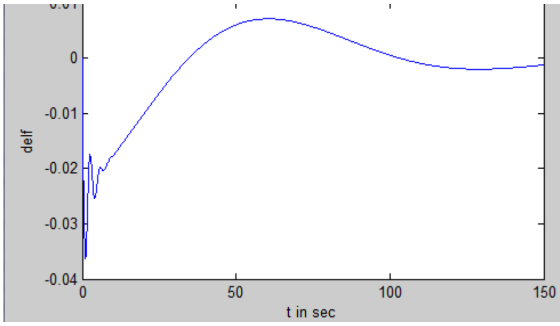

Fig11. (a)Output Two area hydro-thermal power plant for area1

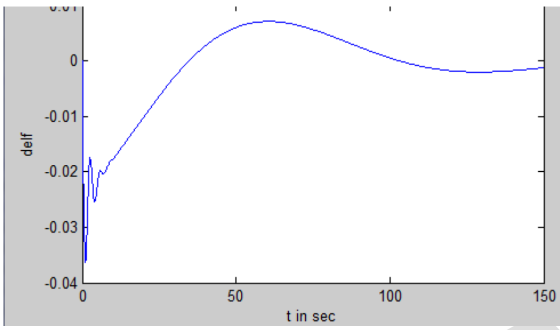

Fig11(b). Output of hydro-power plant with controller values obtained by PSO algorithm

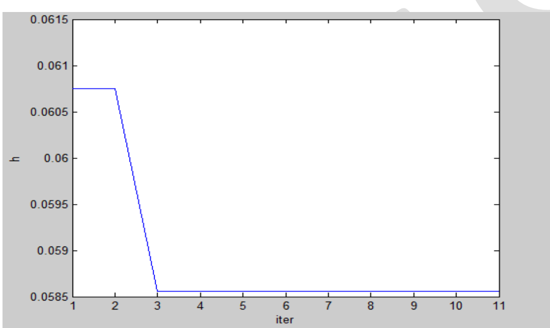

Fig12. Generation vs. iteration curve of hydro thermal power plant

CONCLUSION

The paper presents a case study of designing a controller that can bear desirable results in a two area power system when the input parameters to the system is changed. It was seen that the optimal controller design gives better results and achieved desired reliability under changes in the input parameter. The assumptions taken under consideration strictly followed that the system operation was normal throughout and the simulations were obtained without the presence of the integral controllers. Particle swarm optimization has been successfully applied to the interconnected power station to tune the parameters of automatic generation control systems of the integral-plus-proportional –Derivative type.PSO was implemented in a two-area hydro and hydro-thermal power system.

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