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PERFORMANCE ANALYSIS OF PSO OPTIMIZED PID CONTROLLER IN TWO-AREA MULTI SOURCE POWER SYSTEM

R. Harika
U G Scholar,Department of EEE, Aditya Institute Of Technology and management, Tekkali, A.P

L. Durga
U G Scholar,Department of EEE, Aditya Institute Of Technology and management, Tekkali, A.P

T. Sai suneetha
U G Scholar,Department of EEE, Aditya Institute Of Technology and management, Tekkali, A.P

Y. Rajesh
U G Scholar,Department of EEE, Aditya Institute Of Technology and management, Tekkali, A.P

ABSTRACT

This study extensively represents a practical power system using thermal power plant in each control area. Practical swarm optimization algorithm (PSO) is applied for tuning purpose. Two degree of freedom controller is designed here based on Particle Swarm Optimization (PSO) for controlling the frequency deviation which is a major problem of a two area interconnected power system. In order to improve the performance of supplying power of a power system, error function is minimized. The objective function taken into consideration over here is Integral Time multiplied with Absolute Error (ITAE). Tuning of controllers are done in order to get the gain values or controller parameters such that the desired frequency and power interchange with neighboring systems is maintained within specific value. The dynamic performance of the system is inspected by considering various time response specifications like peak undershoots, peak overshoots and settling time. The analysis includes a performance analysis of PSO optimized PID controller in two area multi source power system.

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1.1 INTRODUCTION

The objectives of the Load Frequency Control (LFC) are to divide the load between generators and to control the tie-line power to pre-specify values and to maintain sensibly uniform frequency. In order to supply reliable electric power with good quality, LFC in power system is very important. Constant frequency is identified as the mark of a normally operating system.

A power plant got to monitor the load conditions and serve consumers entire day. It is therefore irrelevant to consider that uniform power is generated throughout. So depending on load power generation varies. The objective of control strategy is to deliver and generate power in an interconnected system as reliably and economically as possible while maintaining the frequency and voltage within the limits. The system frequency is mainly affected due to change in load, while reactive power depends on changes in voltage magnitude and is less sensitive to frequency. To keep the frequency constant conventional controller is used which controls the turbines used for tuning the generators and also the steady state error of system frequency is reduced by tuning the controller gains. There are different algorithms to optimize the controller gains for load frequency control of an interconnected power system like Genetic Algorithm (GA) but this one is difficult to implement because of its complexity in coding and low speed of convergence. Here in this work Particle Swarm Optimization (PSO) is used because of its simplicity and is not affected size of problem and effectively solve large –scale non-linear optimization problems. Before these algorithms got attention there were methods like Conventional method, Ziegler-Nicholas and LQR method were used to tune the controller.

1.2 LITERATURE SURVEY

Dipayan Guha et al [1] proposed to solve load frequency control (LFC) problem in an inter-connected power system network equipped with classical PI/PID controller using grey wolf optimization (GWO) technique. The main aim of the present study is to design and implement a new evolutionary algorithm (EA) known as grey wolf optimization (GWO) for optimal design of PI/PID controller to solve LFC problem. Four different interconnected power system networks with steam turbine nonlinearity are considered to test the effectiveness of proposed GWO algorithm and simulation results are investigated. Tarkeshwar et al [2] In this paper, load frequency control of an isolated hybrid distributive generation (IHDG) following small step load perturbation is analyzed. A powerful quasi-opposition harmony search algorithm has been used for optimization of the controller Gains of the studied IHDG model. To study the IHDG system behavior and characteristics and to develop a small signal model of IHDG. To apply QOHS algorithm for optimization of the gains of different classical controllers such as integral(I), proportional-integral (PI), integral-derivative (ID) and proportional-integral-derivative (PID) considered individually in the studied IHDG model.

Shengchun Yang et al [3] this paper proposes a MAS-based two-level coordinated control frame to design the LFC for multi-area interconnected power System. The upper-level agent is used to deal with the contradiction between the ACE control and the system frequency recovery and the lower level agents are designed to cooperate with the neighboring agents to realize mutual power support.

D.Das et al [4] the paper presents a simple and efficient method for solving radial distribution network. This method is very efficient and requires less computer memory. The proposed method can easily handle different types of load characteristics. The proposed method involves only the evaluation of simple algebraic expressions of voltage magnitude and no trigonometric terms, as opposed to the standard load flow case. However the proposed method can easily include composite load modeling, if the breakup of the loads is known.

Sheetla Prasad et al [5] This paper addresses non-linear sliding mode controller (SMC) with matched & unmatched uncertainties for load frequency control (LFC) application in three-area interconnected power system. The proposed controller has ability to vary closed-loop system damping characteristics according to uncertainties and load disturbances present in the system. Manoj Kumar Debnath et al [6] here an unique controller termed as 3 degree of freedom proportional integral-derivative (3DOF-PID) controller is recommended for automatic generation control of a hybrid source power system. The scrutinized system includes a unified power system having two area where every area consists of three varieties of generating sources viz. a gas, hydro and a thermal unit.

Sanjoy Debbarma et al [7] in this paper, Two-Degree-of-Freedom-Fractional Order PID (2-DOF-FOPID) controller is proposed for automatic generation control (AGC) of power systems. Proposed controller is tested for the first time on a three unequal area thermal systems considering reheat turbines and appropriate generation rate Constraints (GRCs). Ibraheem a et al [8] this article presents the design of optimal automatic generation control regulators for an interconnected power system operating in a deregulated environment. An extra-high-voltage AC transmission line in parallel with a high-voltage DC link is considered as an area interconnection between the two areas. Haluk Gozde et al [9] In this study, a novel gain scheduling Proportional-plus-Integral (PI) control strategy is suggested for Automatic generation control (AGC) of the two area thermal power system with governor dead-band nonlinearity.. In this strategy, the control is evaluated as an optimization problem, and two different cost functions with tuned weight coefficients are derived in order to increase the performance of convergence to the global optima.

Banaja Mohanty et al [10] this paper presents the design and performance analysis of Differential Evolution (DE) algorithm based Proportional–Integral (PI) and Proportional–Integral–Derivative (PID) controllers for Automatic Generation Control (AGC) of an interconnected power system.

1.3 OBJECTIVE

As we know 50 Hz is normal operating frequency in India and if there is a variation of ± 2.5 Hz then it is going to seriously affect the entire system. For example turbine blades are prone to get damaged in such condition. Also there is a relation between frequency and motor speed which is also going to be affected by frequency variation. The objective of this work is to design a controller based on the optimized parameters obtained from PSO algorithm for restricting the value of frequency to a constant against any variation in load demand. The power flow through the tie line of each area must be maintained to its pre-specified value Minimize the error of the system.

2 System considered

The system considered is a two-area hydrothermal power system taken from the works of Sahu and Chandrakala et al [21] and shown in Figure 1. The parameters of the system are given in Appendix C. The PID is designed for the system and PSO is employed to find out the optimal parameters of PID considering objective function ITAE as considered.

2.1 CONTROLLERS

P CONTROLLER

In general it can be said that P controller cannot stabilize higher order processes For the 1st order processes, meaning the processes with one energy storage, a large increase in gain can be tolerated. Proportional controller can stabilize only 1st order unstable process. Changing controller gain K can change closed loop dynamics. A large controller gain will result in control system with

1. Small steady state error
2. Faster dynamics
3. Smaller amplitude and phase margin

When P controller is used, large gain is needed to improve steady state error. Stable systems do not have problems when large gain is used. Such systems are systems with one energy storage (1st order capacitive systems). If constant steady state error can be accepted with such processes, than P controller can be used. Small steady state errors can be accepted if sensor will give measured value with error or if importance of measured value is not too great anyway.

PID CONTROLLER:

PID controller has all the necessary dynamics: fast reaction on change of the controller input (D mode), increase in control signal to lead error towards zero (I mode) and suitable action inside control error area to eliminate oscillations(P mode). Derivative mode improves stability of the system and enables increase in gain K and decrease in integral time constant Ti, which increases speed of the controller response.

PID controller is used when dealing with higher order capacitive processes (processes with more than one energy storage) when their dynamic is not similar to the dynamics of an integrator (like in many thermal processes). PID controller is often used in industry, but also in the control of mobile objects (course and trajectory following included) when stability and precise reference following are required. Conventional autopilot is for the most part PID type controllers.

2.2 . Particle swarm optimization

Particle swarm optimization (PSO), originated by James Kennedy and R.C. Eberhart in 1995. It is a stochastic (connection of random variable) evolutionary computation method used to explore search space. This technique is based on swarm's intelligence and movement. As this is based on swarm behavior, is a population based technique. The bird generally follows the shortest path for food searching. Based on this behavior, this algorithm is developed. It uses a number of particles where every particle is considered as a point in N-dimensional space. Each particle keeps on accelerating in the search space depending on the knowledge it has about the appreciable solution comparing its own best value and the best value of swarm obtained so far.

3. SIMULATION BLOCK DIAGRAM

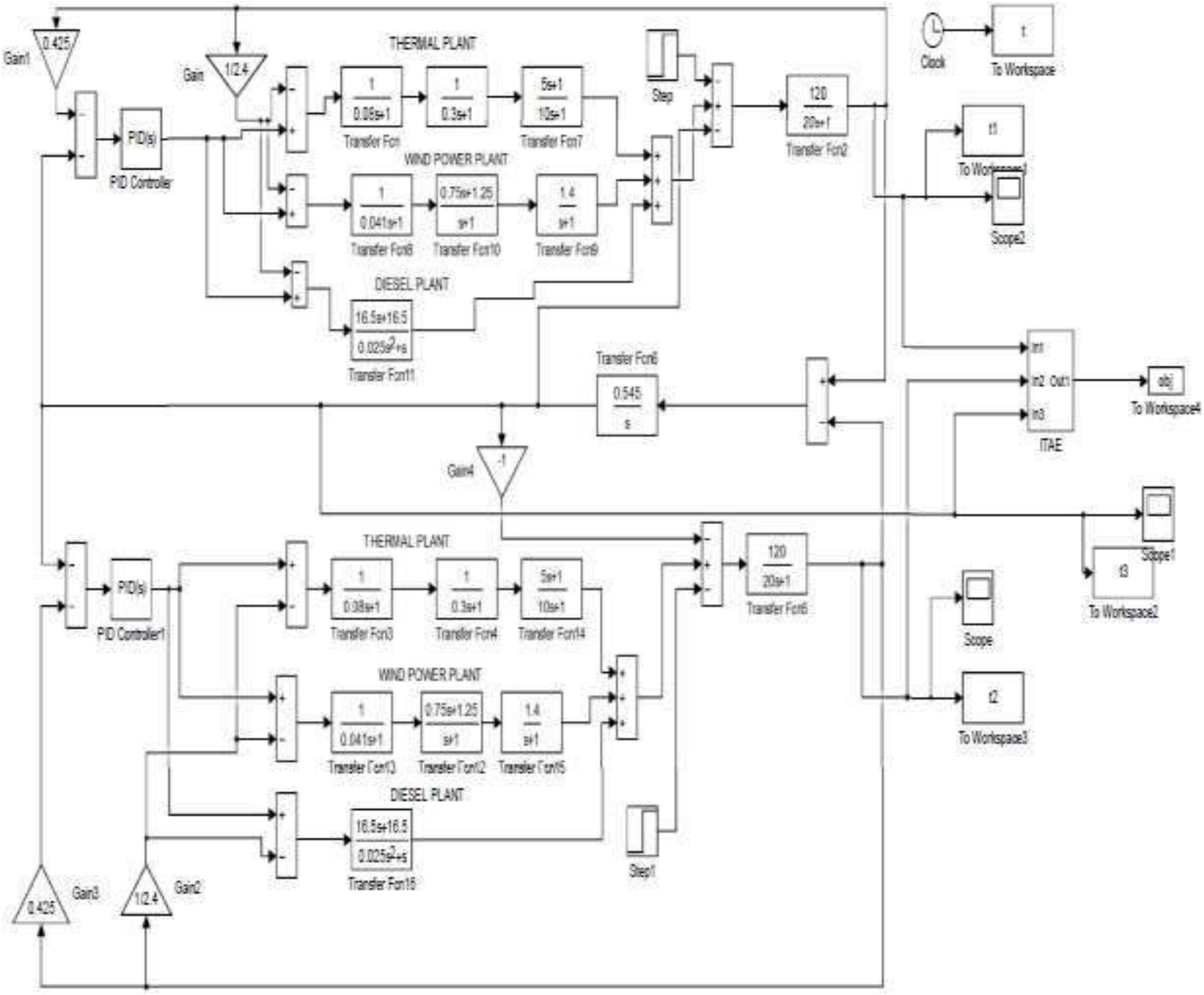

Fig 1 Two Area thermal and hybrid systems with PID & PI controllers:

Controllers	Kp	Ki	Kd	n
PID	0.0007171	2	0.0014	120
PI	-0.6956	0.45	-	-

Table 1: PSO optimized values of PID and PI controller for two area thermal, wind, diesel system

3.2 simulation Results:

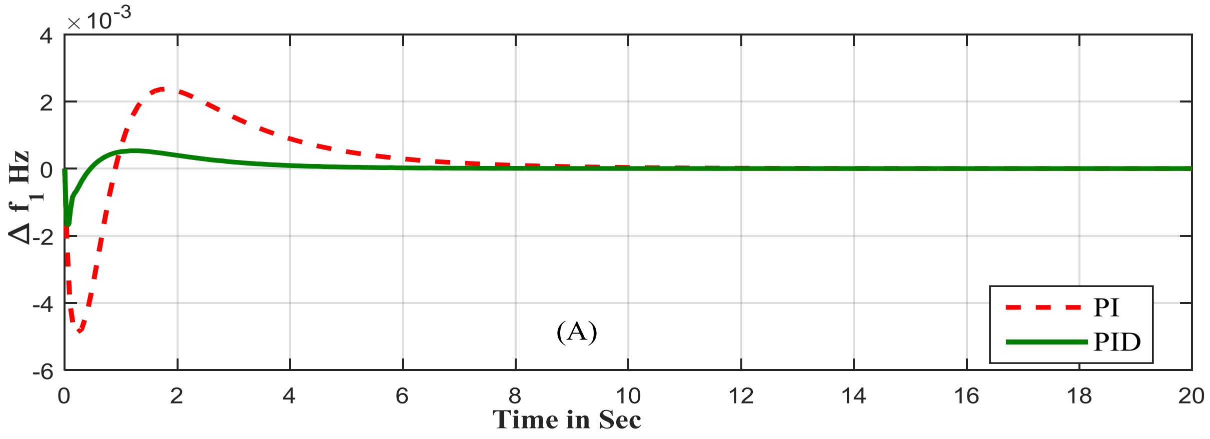

Fig 1.1 Frequency deviation of two area thermal, wind, diesel systems at area-1 for load disturbance of 1%

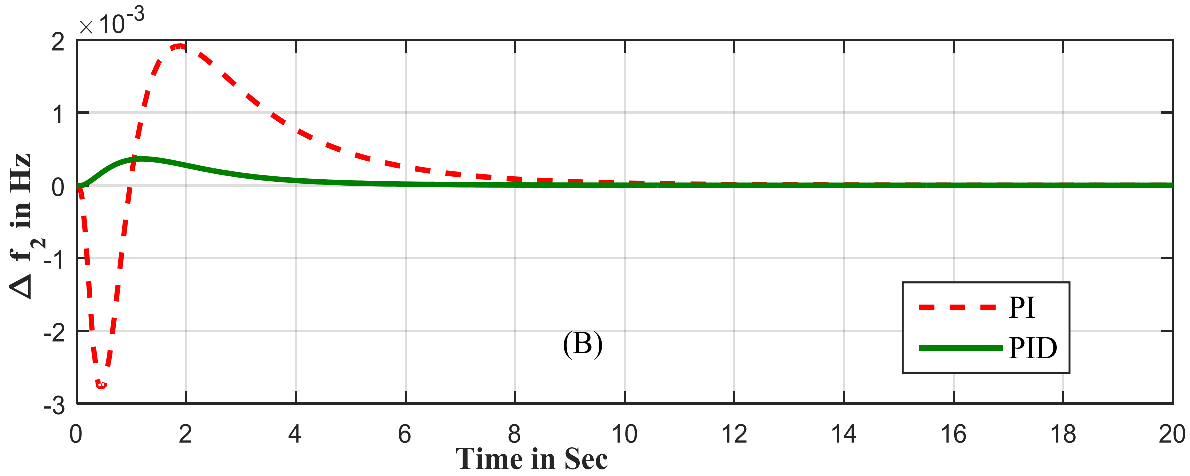

Fig1.2 Frequency deviation of two area thermal, hydro, diesel systems at area-1 for load disturbance of 1%

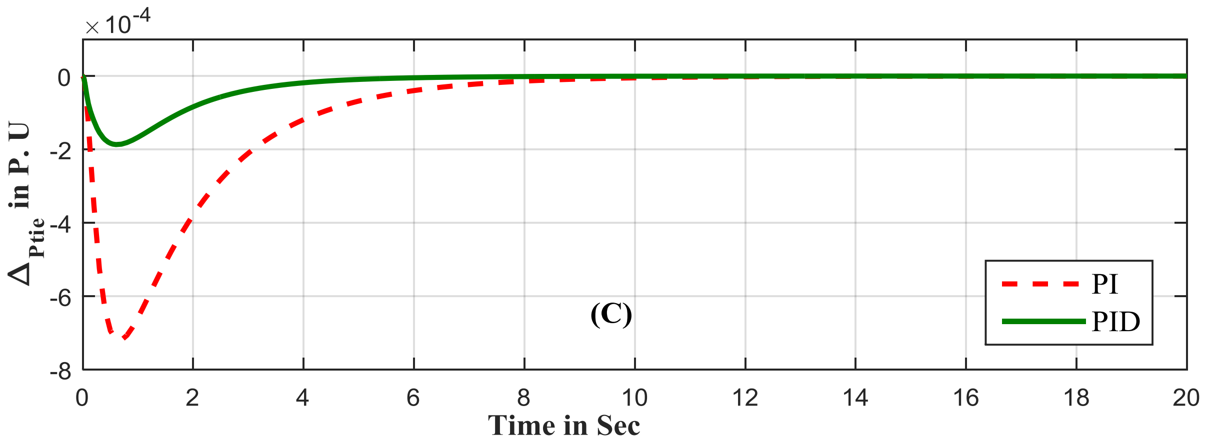

Fig 1.3 Tie-line power deviation for two area thermal, wind, diesel systems

Table- 2 Settling time, Overshoot, Under shoot values of two area thermal system with PID controller

Deviations	Time domain factors	PI	PID
ΔF_1	ST	8.3	5.6
	$OS \times 10^{-4}$	0.0024	0.00053
	US	-0.0049	-0.0017
ΔF_2	ST	8.1	4.9
	$OS \times 10^{-4}$	0.0019	0.00036
	US	-0.0028	-0.000237
ΔP_{tie12}	ST	4.7	4.9
	$OS \times 10^{-4}$	0.0043	0.00089
	US	-0.000719	-0.000186
OBJ	ITAE	0.0449	0.0054

4.1 RESULT ANALYSIS

The settling time of PID controller is 5.6 which is 32.53% better improvement comparing to PI controller , over shoot of PID controller reduces to 77.91% compared to PI controller, under shoot of PID controller reducesto65.30%comparewithPI controller. The settling time of PID controller is 4.9 which is 39.5% better comparing to PI controller, over shoot of PID controller reduces to 81.05% compare with PI controller , under shoot of PID controller reduces to 74.13% compare with PI controller .The settling time of PID controller is 4.9 which is -4.25% better comparing to PI controller ,over shoot of PID controller reduces to 79.3% compare with PI controller and under shoot of PID controller reduces to 74.13% compare with PI controllers for power deviation in area-1&2.

4.2 CONCLUSION

Controlling of power systems in order to meet the demands of consumers is a challenging task that motivates to design optimum controllers. They should have the capability of monitoring the power system like maintenance of frequency and voltage.

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