STUDY OF TUNING OF PID CONTROLLER BY USING PARTICLE SWARM OPTIMIZATION

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ABSTRACT

Many areas in power systems require solving one or more nonlinear optimization problems. Particle swarm optimization (PSO), part of the swarm intelligence family, is known to effectively solve large-scale nonlinear optimization problems. This paper presents a detailed overview of the basic concepts of PSO and its variants. The proposed method utilizes the Particle Swarm Optimization (PSO) algorithm approach to generate the optimal tuning parameters. The paper deals with optimal tuning of proportional integral derivative (PID) controller for controlling the output obtained and hence to minimize the integral of absolute errors. The main objective is to obtain a stable, robust and controlled system by tuning the PID controller using Particle Swarm Optimization (PSO) algorithm. It is necessary to use PID controller to increase the stability and performance of the system. Fast tuning of optimum PID controller parameter yield high quality solution. This paper demonstrated in detail how to employ the PSO method to search efficiently the optimal PID controller parameters. The proposed approach had superior features, including easy implementation and good computational efficiency. KEY WORDS: PSO, PID Controller types, PID controller parameters. .

1. INTRODUCTION

The Electric power grid is the largest man-made machine in the world. It consists of synchronous generators, transformers, transmission lines, switches and relays, active/reactive compensators, and controllers. Various control objectives, operation actions and/or design decisions in such a system require an optimization problem to be solved. For such a nonlinear non-stationary system with possible noise and uncertainties, as well as various design/operational constraints, the solution to the optimization problem is by no means trivial.

Classification of Controller

There are mainly three types of controllers

- Proportional controllers.
- Integral controllers.
- Derivative controllers

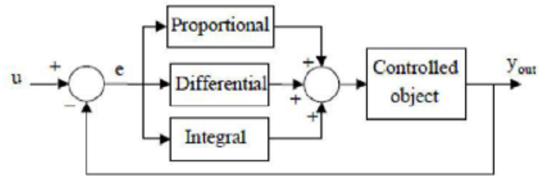
Combinations of these three controllers are written below:

- Proportional and integral controllers.
- Proportional and derivative controllers
- Proportional integral and derivative controllers.

The proportional controller is one in which the actuating signal is directly proportional to the error signal. The integral controllers are the controllers in which the actuating signal is directly proportional to the integral of the error signal. The derivative controller is one in which the actuating signal is directly proportional to the derivative of the error signal. PD controller improves the transient response of the system. PI controller reduces the steady state error present in the system. PID controller is the combination of PD and PI controller. The PID controller algorithm involves three separate constant parameters i.e P,I & D. PID controller operates directly on error signal which is the between desired output and actual output. By tuning the three parameters in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set point, and the degree of system oscillation.

II. DESIGN OF PID CONTROLLER

One of the most common controlling methods in the market is the PID controller. Application of the PID controller involves choosing the K_P, K_I and K_D that provide satisfactory closed-loop performance. These parameters must be selected so that the characteristics response speed, settling time and proper overshoot rate, all of which guarantee the system stability, would be satisfied.



The transfer function of the system is given as

$$G_{PID}(s) = K_p + \frac{K_I}{s} + K_D s = \frac{K_D s^2 + K_p + K_I}{s}$$

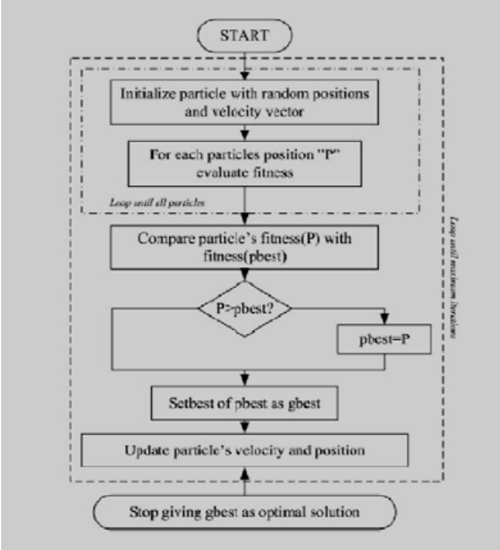
Study of Optimization Technique (PSO)

In 1995, Kennedy and Eberhart first introduced the particle swarm optimization (PSO) method. It is one of the optimization techniques and a kind of evolutionary computation technique. The features of the method are as follows

- The method is developed from research on swarm such as fish schooling and bird flocking.
- It can be easily implemented, and has stable convergence characteristic with good computational efficiency.

In this method each particle keeps track of its coordinates in the problem space, which are associated with the best solution it has achieved so far. This value is called pbest. An other best value that is tracked by the global version of the particle swarm optimizer is the overall best value, and its location , obtained so far by any particle in the group is called gbest.

The flow chart for Particle Swarm Optimization is explained as under



PSO Algorithm

Step 1. Initialize an array of individuals with random positions and their associated velocities to satisfy the inequality constraints.

Step 2. Check for the satisfaction of the quality constraints and modify the solution if required.

Step 3. Evaluate the fitness function of each individual.

Step 4. Compare the current value of the fitness function with the individual's previous best value (pbest). If the current fitness value is less, then assign the current coordinates (positions) to pbestx.

Step 5. Determine the current global minimum fitness value among the current positions.

Step 6. Compare the current global minimum with the previous global minimum (gbest). If the current global minimum is better than gbest, then assign the current global minimum to gbest and assign the current coordinates (positions) to gbestx.

Step 7. Update the velocities and individual's position according to (1) and (2).

Step 8. Repeat Step 2-7 until optimization is satisfied or the maximum number of iterations is reached.

Particle Swarm Optimization is one of the modern heuristic algorithms. It was developed through simulation of a simplified social system, and has been found to be robust in solving continuous nonlinear optimization. The PSO technique can generate a high quality solution within shorter calculation time and stable convergence characteristics. The PSO method is an excellent optimization methodology and a promising approach for solving the optimal PID controller parameters problem. The PSO concept consists of, at each time step, changing the velocity of each particle toward its pbest and gbest locations.

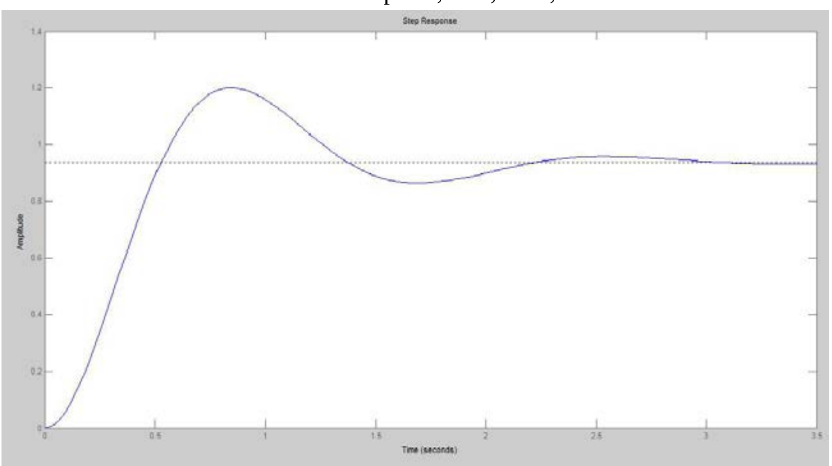
III. TUNING OF PID CONTROLLER Proportional-Integral Derivative (PID) controllers have been widely used for speed and position control of various applications. Among the conventional PID tuning methods, the Ziegler–Nichols method may be the most well known technique. For a wide range of practical processes, this tuning approach works quite well. However, sometimes it does not provide good tuning and tends to produce a big overshoot. Therefore, this method usually needs retuning before applied to control industrial processes. To enhance the capabilities of traditional PID parameter tuning techniques, several intelligent approaches have been suggested to improve the PID tuning, such as those using genetic algorithms (GA) and the particle swarm optimization (PSO) . With the advance of computational methods in the recent times, optimization algorithms are often proposed to tune the control parameters in order to find an optimal performance.

The proportional part of the PID controller reduces error responses to disturbances. The integral term of the error eliminates steady-state error and the derivative term of error dampens the dynamic response and thereby improves stability of the system. The parameter settings of a PID controller for optimal control of a plant (process) depend on the plant's behaviour. To design the PID controller the engineer must choose the tuning way of design parameters to improve the transient response as well as the steady-state error. In the design of a PID controller, the three gains of PID must be selected in such a way that the closed loop system has to give the desired response. The desired response should have minimal settling time with a small or no overshoot in the step response of the closed loop system.

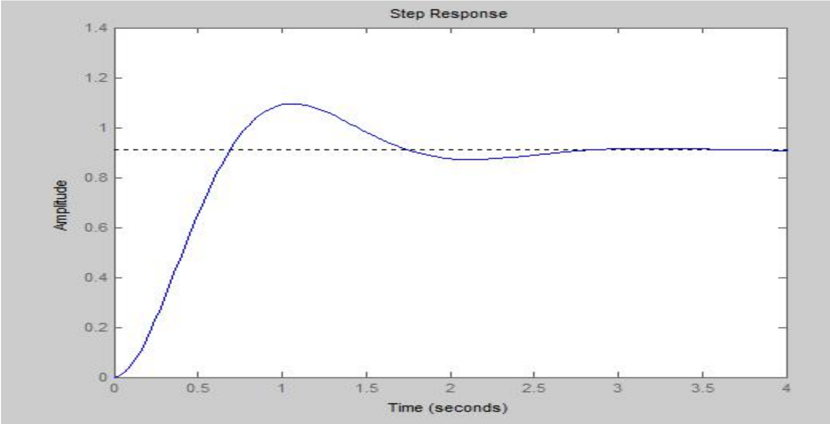
Effects of increasing parameters independently

Parameter	Risetime	Overshoot	Settling time	Steady state error	Stability
K_p	decrease	increase	Small change	Decrease	Degrade
K_i	decrease	increase	increase	Eliminate	Degrade
K_d	Minor change	decrease	decrease	No effect	Improve if K_d small

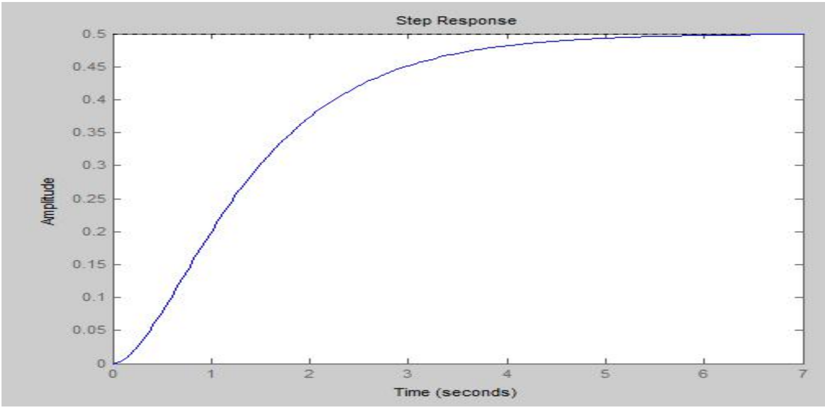
Case I kp=15;ki=0;kd=0;



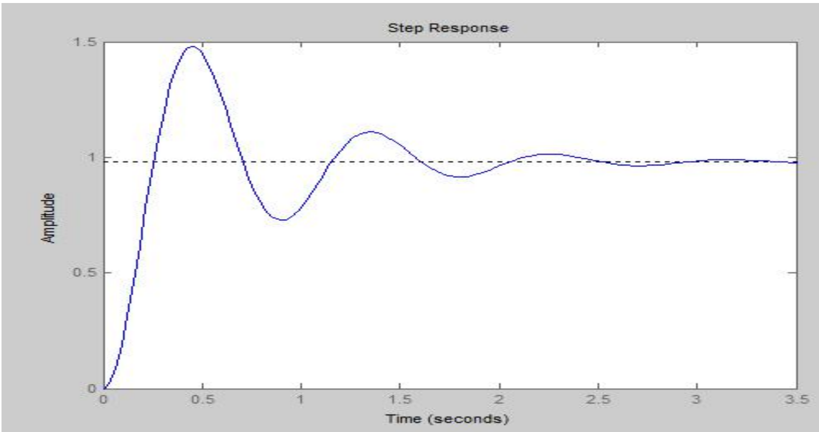
Case II   kp=10;ki=0;kd=0;



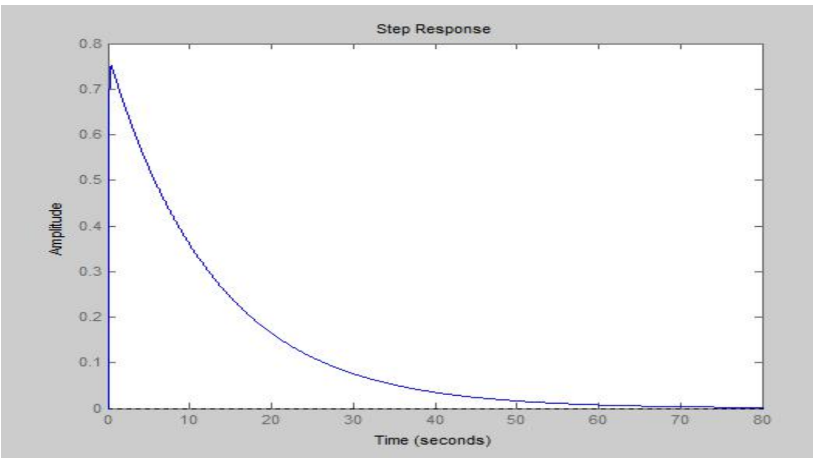
Case III kp=1;ki=0;kd=0;



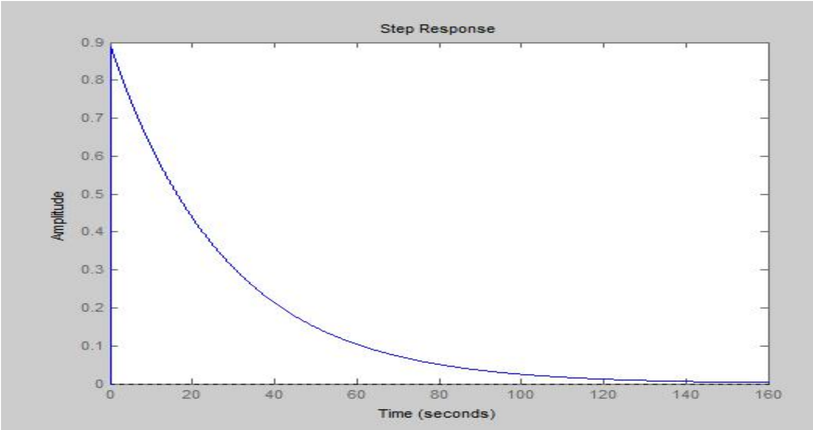
Case IV kp=50;ki=0;kd=0;



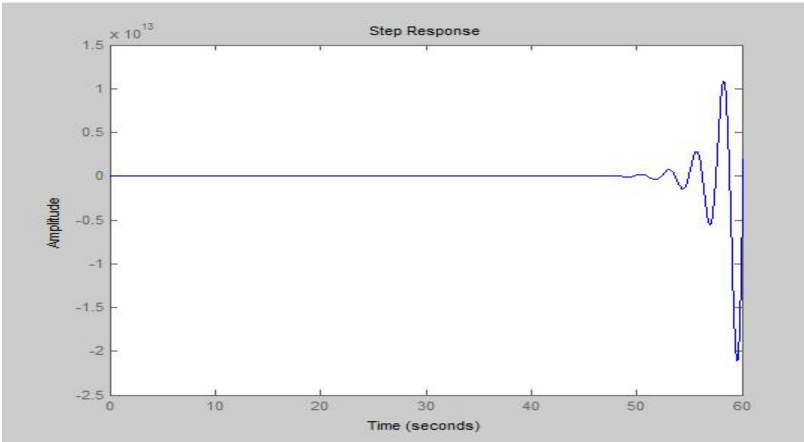
Case V kp=0;ki=0;kd=10;



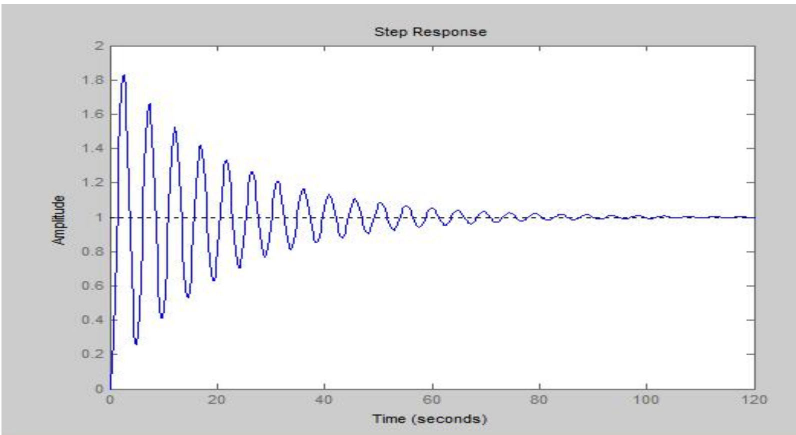
Case VI kp=0;ki=0;kd=25;



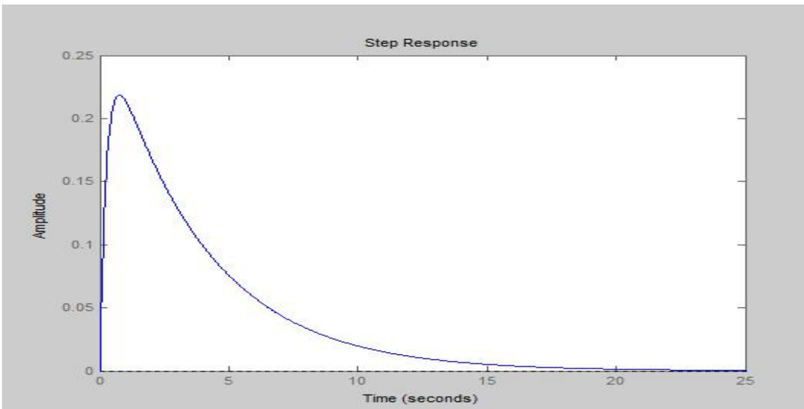
Case VII kp=1;ki=25;kd=0;



Case VIII kp=1;ki=5;kd=0;



Case IX kp=0;ki=0;kd=1;



IV. CONCLUSION

It is shown graphically that there is a substantial improvement in the time domain specification in terms of lesser rise time, peak time, settling time as well as a lower overshoot. Hence by varying different parameters of the PID controller the response of the system is changing. Hence by changing k_p ,k_i, and k_d the response of the system is improved. Also the peak overshoot, the rise time and the settling time of the system is reduced. Hence this method is a design method for determining the PID controller parameters . It can obtain higher quality solution with better computational efficiency.

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