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# Particle Swarm Optimization in the usage consequences for low power in optimized PID Controller.

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**Abstract-** Controllers are used to modify the behaviour of a gadget so it behaves in a particular suitable way. Proportional- Integral-Derivative controller has excessive effectiveness, simplicity in implementation so that, it's miles the maximum broadly used controller in industries for many packages. Conventional approach of tuning PID controller creates massive overshoot. This is an appropriate result for some cause but not most suitable for all applications. The Artificial Intelligence (AI) method of Particle Swarm Optimization algorithm is employed in tuning of PID controller. The important intention of this particular work is to evaluate the traditional technique and PSO method of tuning the PID controller and to prove that PSO technique is greener than the traditional approach in tuning the control parameters. Such sort of optimized controllers can be used for low energy programs with excessive efficiency.

**Keywords**—PID controller, Ziegler Nichols method, CHR method, particle swarm optimization, simulation, comparison.

## 1. Introduction

Control system idea advanced as an engineering field and because of universality of the standards involved, it's far extended to numerous fields like financial system, sociology, biology, medicinal drug, etc. Control concept has performed an important position in the enhance of engineering and science. The automatic manipulate has come to be an indispensable a part of cutting-edge manufacturing and commercial process. The optimization techniques efficient in enhancing the step response than computational techniques inside the recent instances [1-2]. In [3], a gadget may be optimized by way of the use of Evolutionary algorithm like Particle Swarm Optimization. A solid, robust and controlled device by tuning the PID controller using Particle Swarm Optimization [4]. PID controllers are used in industrial plant life to govern the armature managed DC motor the usage of conventional techniques consisting of Continuous cycling technique and ZN technique have been in comparison with Genetic Algorithm through improving the performance indices [5]. The comparison among PSO primarily based PID overall performance and the ZN based PID overall performance. The effects display the gain of the PID tuning the usage of PSO primarily based optimization approach [6]. PID controller is tuned based on distinct objective functions [7]. To develop an Artificial intelligence automated PID tuning scheme the usage of PSO algorithm which can mechanically acquire the PID parameters at some point of plant operation in a recurring way [8]. To manage the velocity of the DC motor by PID controller the use of Ziegler Nichols method tuning set of rules which produces excessive peak overshoot [9].

This work proposes to broaden an optimized PID tuning approach using PSO set of rules for low power programs with excessive efficiency. Section II describes the PID controller, section III offers an outline of the conventional methods phase IV describe a top-level view of the PSO set of rules and finally, segment V we speak the simulation result and conclusion is drawn in segment VI.

## 2. PID Controllers

A Proportional-integral-derivative (PID) controller is a control loop feedback controller commonly used in industrial control systems. Figure 1 depicts the block diagram of PID controller. In this model, **P** is proportional to the present value of the set point. P controller produce the large gain such that reduces the steady state error. **I** is proportional to the past value of the set point. I am integral term that eliminates the residual steady state error. **D** proportional to the future value of the set point. D mode is used to improve the stability of the system or predict the error.

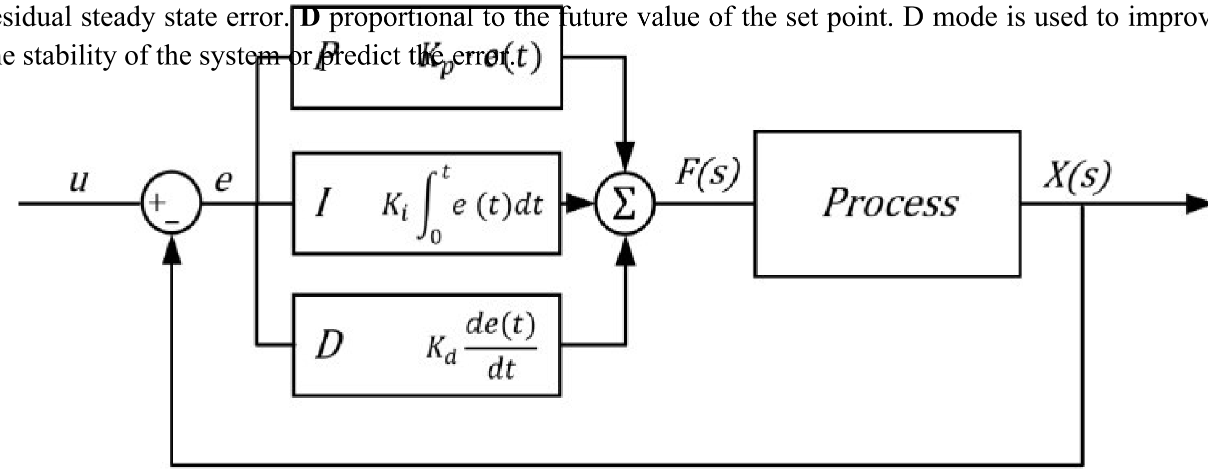


**Fig 01**: Block diagram of PID controller.

The transfer function of the PID controller is,

$$G_s = k_p + \frac{k_i}{s} + k_d . s$$

The output of the PID controller can be written as,

$$U(t) = k_p . e(t) + k_i \int e(\tau) . d\tau + k_d \frac{de(t)}{dt}$$

Where, $K_p$, $K_i$, $K_d$ are the proportional, integral, derivative gains of the PID controllers respectively.

A PID controller determines the error valve as the difference between required set point and a measured process variable. The controller attempts to minimize the error over time by adjustment of a control variable to a new valve determined by a weighted sum.

## 3. Tunning of PID Using Conventional Methods

### 3.1 Ziegler Nichols (ZN) Method

ZN tuning is based on the open-loop step response of the system. The process time parameters are used to determine the controller's tuning parameters. ZN tuning is based on the closed-loop tuning method that requires the determination of the ultimate gain and ultimate period. This method can be interpreted as a technique of positioning one point on the Nyquist curve. This can be achieved by adjusting the controller gain till the system undergoes sustained oscillations, while maintaining the integral time constant at infinity and the derivative time constant at zero.

The PID controller has four performances indices such as ISE, IAE, ITSE, ITAE. In this paper we are taking two indices ISE, IAE.

#### 3.1.1 Integral Square Error

ISE integrates the square over time. ISE will penalize large errors more than smaller ones. control system specified to minimize ISE will tend to eliminate large errors quickly, but will tolerate small errors persisting for a long period of time often this leads to fast responses, but with considerable, low amplitude, oscillation.

$$ISE = \int_0^{\infty} e^2(t)\,dt$$

**3.1.2 Integral Absolute Error**

IAE integrates the absolute error over time .it does not add weight to any of the errors in a system response. It tends to produce reduced speed than ISE optimal systems, but usually with less sustained oscillation.

$IAE = \int_0^{\infty} ¿ e(t) \vee ¿ dt ¿$For some applications it might result in aggressive gain and overshoot.

### 3.2 **Chien Hrones Reswich(CHR) Method**

This method that has proposed by "Chien, Hrones and Reswich" is a modification of open loop Ziegler and Nichols method. They proposed to use "quickest response without overshoot" or "quickest response with 20% overshoot" as design criteria to achieve desired performance. They also made the important observation that tuning for set point responses and load disturbance responses are different. To tune the controller according to the CH-R method the parameters are determined in the same manner of the Z-N method. The tuning rules based on the 20% overshoot layout criterion are quite just like the Z-N technique, at the same time as zero% overshoot criteria is used, the gain and the by-product time are smaller and the integral time is larger. This defines that the proportional movement and the vital movement, in addition to the by-product motion, are smaller. This method is used for fundamental PID controller. It isn't appropriate for all of the sensible controller.

## 4. Tunning of PID using PSO

### 4.1 Overview of PSO Algorithm

Particle swarms changed into first evolved by using Eberhart and Kennedy in 1995. PSO set of rules, that's derived for optimizing tough numerical functions and primarily based on metaphor of human social interplay, is able to mimicking the capability of human societies to technique understanding. It has the most important aspect methodologies: synthetic life (which includes fowl flocking, fish education and swarming) and, evolutionary computation. Its idea is that capacity answers are flown via hyperspace and are multiplied closer to higher or greater premiere solutions. As in evolutionary computation paradigms, the idea of health is hired and candidate answers to the problem are termed debris or every so often individuals, every of which adjusts its flying based totally at the flying experiences of each itself and its associate. It maintains tune of its coordinates in hyperspace which can be related to its previous nice fitness answer and additionally of its counterpart corresponding to the overall exceptional price received up to now by using some other particle in the populace. The basic operational principle of the particle swarm is applicable for the flock of birds or fish or for a set of humans. While looking for food, the birds are either scattered or cross together earlier than they find the location in which they can find the food.

#### 4.1.1 Implementation of PSO Based PID Tuning

PSO is implemented to tune the PID gain parameters for the required system. Optimized PID controller parameters can yield a good system response and result in minimization of performance index. The fitness function is fixed and find the suitable parameters to achieve the desired output. PSO algorithm is further improved via using a time decreasing inertia weight, which leads to a reduction in the number of iterations. The fitness function is given by,

*Fitness function* = { ¿

**5. Results**

The paintings centered to evaluate the conventional strategies, ZN and CHR with PSO set of rules. Particle Swarm Optimization (PSO) algorithm is used to get the optimized parameter cost of PID controller. Initially Ziegler Nichols method is in comparison with Chien- Hrones –Reswick (CHR) approach and to get the response of the transfer feature. The ZN technique is defined with exceptional indices like ISE and IAE the usage of Simulink and their response is analyzed. The effects of ZN, ZN-ISE, ZN-IAE and CHR are in comparison with the reaction of PSO. Comparative outcomes for the PID controllers are given underneath in Table I wherein the step reaction performance is evaluated based totally on the height fee, peak time and settling time. Optimized gain values are given within the table II primarily based at the fitness characteristic.

| Tuning methods | Peak Value(v) | Peak Time(s) | Settling Time(s) |
|---|---|---|---|
| ZN | 1.55 | 1.2 | 6.1 |
| ZN-ISE | 1.455 | 0.8 | 3.8 |
| ZN-IAE | 1.02 | 0.5 | 3.2 |
| CHR | 1.33 | 0.2 | 2.5 |
| PSO | 1.325 | 0.009 | 0.055 |

**Table 1**: Comparison of PID tunning methods

| Fitness Value | 83.4507 | | |
|---|---|---|---|
| Optimized $K_p$, $K_i$, $K_d$ values | $K_p$ - 3.6000 | $K_i$ - 3.7995 | $K_d$ - 0.8527 |

**Table 2**: Fitness and optimized gain value.

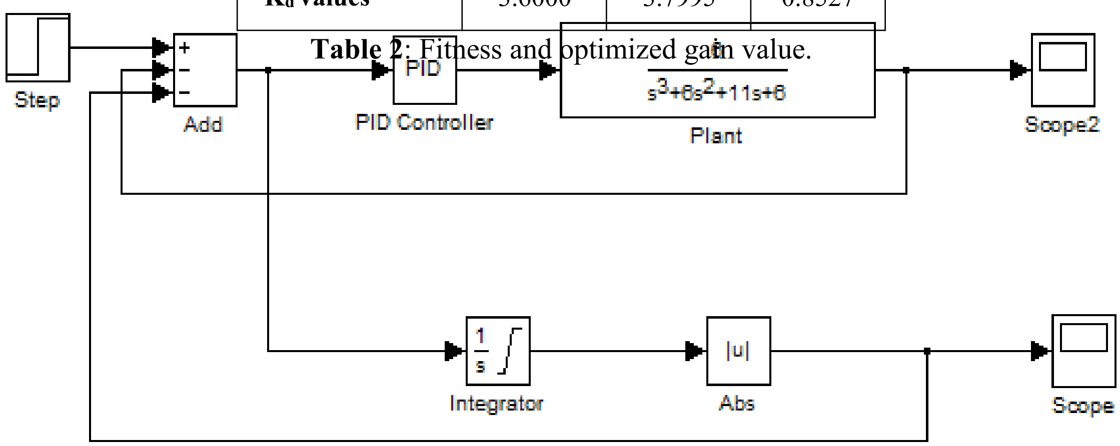

**Fig.02** Simulation model

Figure 2 shows the Simulink models of different indices like ISE and IAE using MATLAB Simulink. The system transfer function is different for different applications. Figure 3 depicts the simulation results of the comparisons of the conventional methods and PSO.

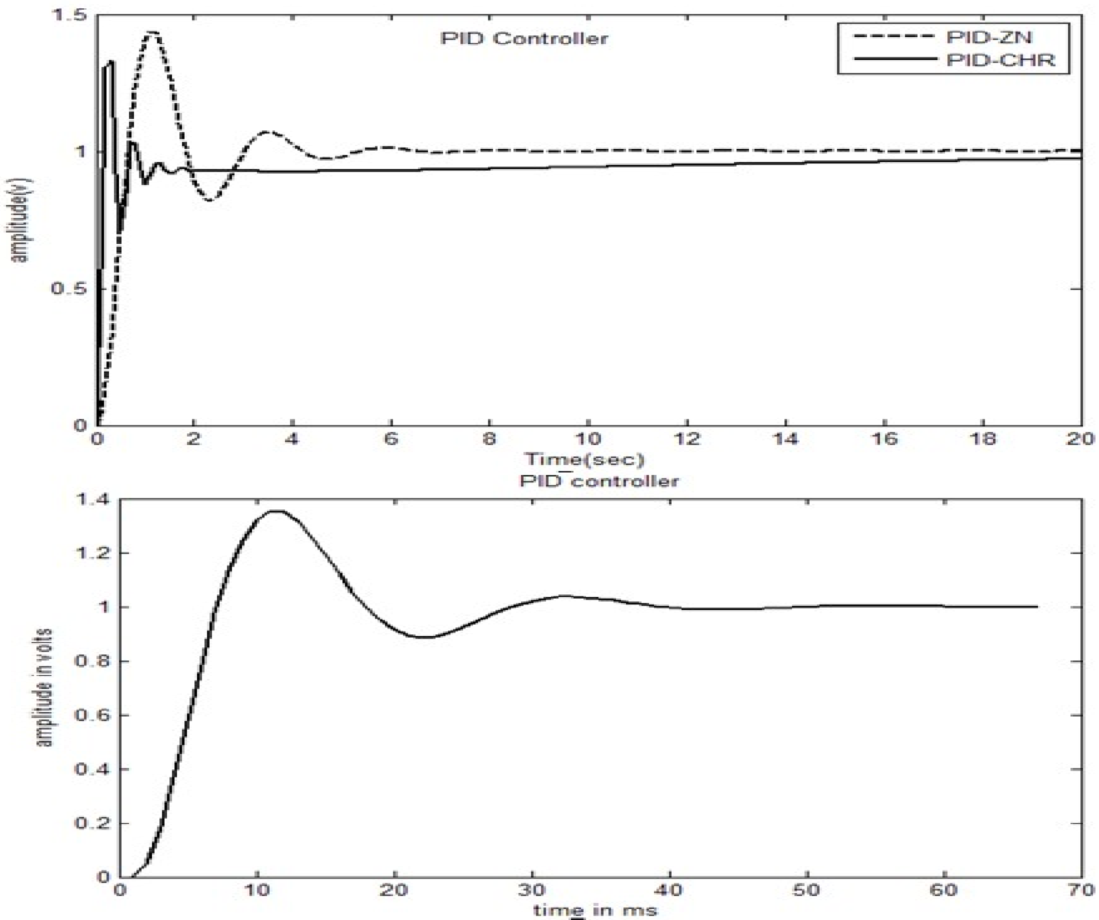


**Fig.03** simulation output

## 6. Conclusion

Implementation of PID Controller Using Particle Swarm Optimization has been effectively simulated and confirmed with MATLAB / Simulink version. It is in tuning the controllers that the best gains in overall performance can be discovered. A huge sort of tuning techniques exists, although of the two discussed in this newsletter, the PSO algorithm method affords the only approach in tuning a controller. It becomes shown, through assessment in their responses that the PSO algorithm has outperformed the Ziegler Nichols approach in terms of the device overshoot, settling time and rise time. Also, the overall performance index cost acquired the usage of the proposed PSO algorithm is less than of the Ziegler-Nichols approach. The performance of the PSO set of rules of tuning a PID controller has been proved to be better than the heuristic Ziegler-Nichols technique. From the effects, the implemented PID controller the use of PSO algorithm indicates advanced performance over the traditional approach of Ziegler-Nichols, in terms of the gadget overshoot, settling time. However, the conventional method provides us with the initial PID advantage parameters for gold standard tuning. Therefore, the advantage of using a contemporary synthetic intelligence optimization technique is determined as a complement answer to improve the overall performance of the PID controller designed by traditional technique. Of route there are numerous strategies that can be used because the optimization equipment and PSO is one of the recent and green optimization equipment.

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