GA based PID Tuning for BLDC Motor

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Abstract –The aim of this paper is to design a position controller of a DC motor by selection of a PID parameters using genetic algorithm.PID controller is tuned with GA technique using MATLAB software. This paper compares two kinds of tuning methods of parameter for PID controller. One is the controller design by the genetic algorithm, second is the controller design by conventional method. It was found that the proposed PID parameters adjustment by the genetic algorithm is better than the conventional method.

Keywords- BLDC, Genetic algorithm, PID controller, Ziegler Nichols Method, K_P, K_i, & K_D

I. Introduction

The Brushless Direct Current (BLDC) motors are gaining grounds in the industries, especially in the areas of appliances production, aeronautics, robotics, computer peripherals, consumer and industrial automations and so on. The reason is that BLDC motors offer many advantages over the conventional brushed DC motors, including higher efficiency, reliability, higher starting torque, reduced mechanical and electrical noises, and overall reduction of electromagnetic interference (EMI). The motor part of a brushless motor is often a permanent magnet synchronous motor, but can also be a switched reluctance motor, or induction motor.

PID is remarkable control strategy, widely use in processes industries such as oil and gas, chemical, petrochemical, pulp and paper, food and beverage. PID controller has been proven in terms of reliability and robustness in controlling process variable ranging from temperature, level, pressure, flow, pH etc. Other factors that attracted industries to choose PID controller could be due to low cost, easy to maintain, as well as simplicity in control structure and easy to understand.

II. BLDC Motor

The speed of the BLDC motor is controlled by means of a three-phase and half-bridge pulse-width modulation (PWM) inverter. The dynamic characteristics of BLDC motors are similar to permanent magnet DC motors.

The characteristic equations of BLDC motors can be represented as

$$V_{app}(t) = L\frac{di(t)}{dt} + R\, i(t) + v_{emf}(t)$$

$$v_{emf} = K_b\omega(t)$$

From the characteristic equations of the BLDC motor, the transfer function of speed model is obtained

$$T(t) = K_t\, i(t)$$

$$T(t) = J\frac{d\omega(t)}{dt} + D\,\omega(t)$$

$$\frac{\omega(s)}{Vapp(s)} = \frac{Kt}{LJS2+(LD+RJ)S+KtKs}$$

III. PID Controller

Various strategies have been used to implement the controller. Three of the most common are:

- (**P**) Proportional error correction. The difference between the set point and actual system output is amplified and fed back to provide the correction signal. The larger the deviation from the set point, the larger the correction signal.
- (**I**) Integral error correction. Persistent differences between the set point and actual system output accumulate over time, until they become large enough to drive the system output back toward the set point.
- (**D**) Derivative error correction. The correction signal opposes rapid deviations in system output, reducing the response to disturbances and transient conditions.

There is nothing that requires these strategies to be utilized in isolation. Usually, some combination provides better performance. The multipliers **P**, **I** and **D** specify the degree to which each of the correction terms affects the controller's output.

The transfer function of PID Controller is

$$C(s) = \frac{U(s)}{E(s)} = K_p + \frac{Ki}{s} + K_d s$$

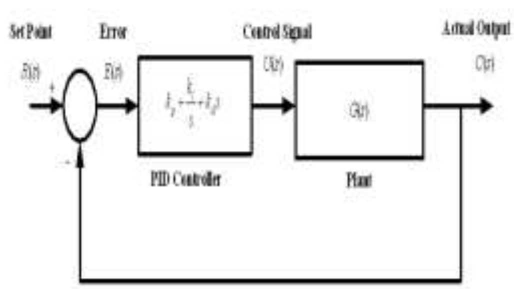

Fig:1 PID control structure

IV. PID Control Tuning

The process of computing and setting the optimal values of *Kp*, *Ki* and *Kd* to get desired response from a control system, called tuning. PID controllers are mostly tuned by Ziegler-Nicholas method. Many model based controller techniques such as internal model control are used in conjunction with PID controller to improve the dynamic response of the process. Apart from conventional tuning methods there are many soft computing based intelligent tuning rules like Particle Swarm Optimization (PSO), Genetic Algorithms (GA) etc. The soft computing techniques for a PID controller considerably reduce the overshoot and rise time as compare to any other tuning method.

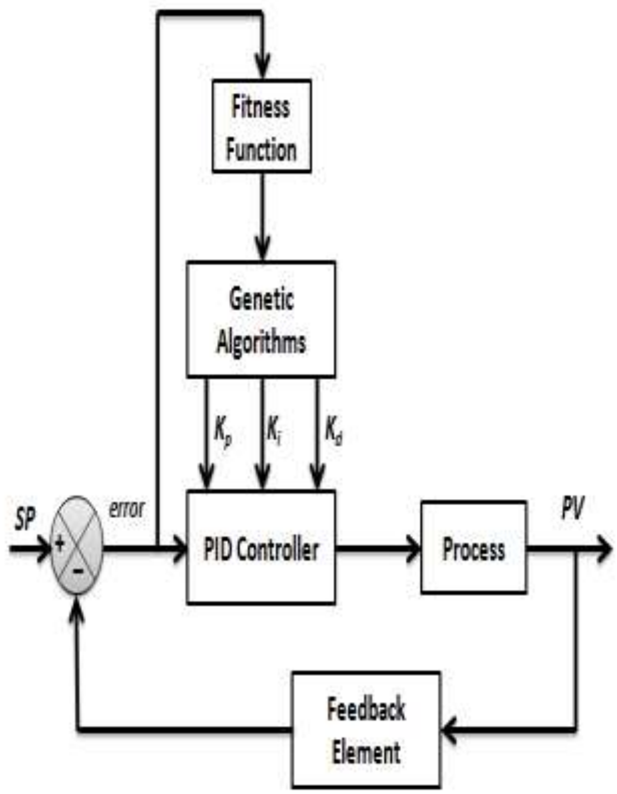

Fig:2 Block Diagram of Genetic Algorithms Based PID Controller

V. GENETIC ALGORITHMS (GA)

The Genetic Algorithm is method for solving optimization problem that is based on natural selection, the process that drives biological evolution. The GAs repeatedly modifies a population of individual solutions. At each step the GAs select individual at random from the current population to be parents and uses them to produce the children for the next generation. Over successive generation, the population evolves toward an optimal solution. Three main steps of GAs are :

Selection selects the individuals, called parents that contribute to the next generation.

Crossover combines two parents to form children for the next generation.

Mutation apply random changes to individual children.

VI. GENETIC ALGORITHMS BASED PID CONTROLLER

For the design of the GA-based PID controller, first an initial population of the GA is generated by random, this contains binary strings, where a string represents the proportional, integral and derivative gains (Kp, Ki, Kd). The objective function is required to evaluate the best PID controller for the system. An objective function could be created to find a PID controller that gives the smallest overshoot, fastest rise time or quickest settling time. However, in order to combine all of these objectives it is needed to design an objective function that will minimize the performance indices of the control system instead. Each chromosome in the population is passed into the objective function one at a time. The chromosome is then evaluated and assigned a number to represent its fitness. The genetic algorithm uses the chromosome's fitness value to create a new population consisting of the fittest members. Each chromosome consists of three separate strings constituting a P, I, and D term. When the chromosome enters the evaluation function, it is split up into its three terms. The newly formed PID controller is placed in a feedback loop with the system transfer function. This will result in a reduction of the compilation time of the program. The system transfer function is defined in another file and imported as a global variable. The controlled system is then given a step input and the error is assessed using an error performance criterion such as Integral Square Error (ISE), Integrated Absolute Error (IAE). The chromosome is assigned an overall fitness value according to the magnitude of the error.

GA based parameter

Parameter	Value/Type
Population Size	20
Selection Method	Tournament
Crossover Method	Heuristic
Crossover Probability	0.35
Mutation Probability	0.02

GA based analysis

Parameter	Value
Rise Time	Zero
Settling Time	5.9711
Peak Time	3
Peak Overshoot	7.2727
Integrated Absolute Error (IAE)	1.401

VII. RESULT

In the simulink model, PID controller tuned with ZN and GA technique are fed through the step response. These tuned PID controller give the output to the transfer function of the BLDC motor. The output response of all the techniques is obtained in a graph and then comparison is made.

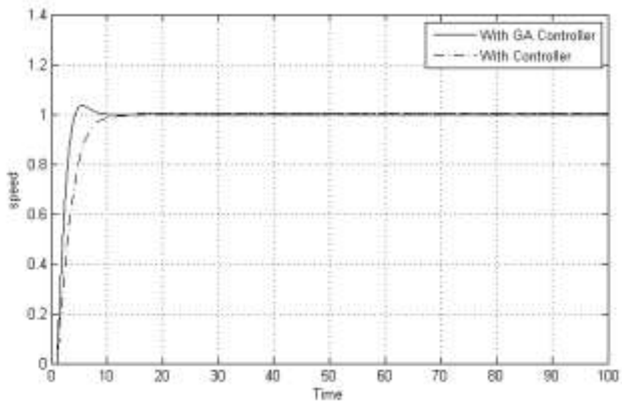

Fig:3 Output response with GA tuned PID

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