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GA Tuned PID Controller for Position Control of BLDC Motor

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Abstract: In this paper position of the BLDC motor can be controlled using PID controller. The Proportional gain (KP), Integral gain (KI), Derivative gain (Kd) of the PID controller are tuned using genetic algorithms. The main aim of this paper is to analyze the implementation of Genetic Algorithm (GA). The main aim of the paper is to tune the PID controller whose parameters are controlled by genetic algorithm. The results obtained from GA algorithms were compared with considered objective functions. It was found that the Genetic Algorithm with objective IAE+MSE outperformed other considered objective functions.

Key words: BLDC Motor, PID Controller, Genetic algorithm (GA), IAE, MSE.

I. INTRODUCTION

Brushless DC Motors have high efficiency, high torque and low volume due to which these are increasingly used in many industrial applications. By analysing a complete model of four quadrant control of BLDC Motor operation can be controlled with GA optimized PID controller for its position control to obtain maximum speed operation. The precise control of Rotor position of BLDC motor can be performed by using various techniques. One of the widely used techniques is genetic algorithm. Brushless dc motor is the motor operated on the dc supply providing us highly efficient and reliable permanent magnet synchronous motor. These motors are required for heating, ventilation and for small horse power requirements. This type of motor is required in those industries which have varying system loads, parameters and inertia. So their speed control becomes the necessary for the motor to act as high performance drives. As the name suggests the motors does not have the brushes with it. It has concentrated winding wound on the rotor. The motor acts as self controlled variable frequency drives.

Conventional feedback controllers, such as the PID or the linear quadratic, need accurate mathematical models describing the dynamics of the system under control. This can be a major limiting factor for systems with unknown varying dynamics. So there is need of much better and fast speed control techniques for brushless dc motor. In this dissertation genetic algorithm and particle swarm optimization have been used as global search method to find the parameters that provide us the best solution for PID controller that is to be tuned. The self-controlled variable frequency drives employing a trapezoidal PMSM motors are called brushless dc motors (BLDCM). There are many similarities between BLDC permanent magnet synchronous motor and a dc motor.

II. MODELLING OF 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. Thecharacteristic equations of BLDC motors can be represented as

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

$$v_{emf} = K_b G\dot{O}(t)$$

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

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

$$T(t) = J\frac{dG\dot{O}(t)}{dt} + D\, G\dot{O}(t)$$

$$\frac{G\dot{O}(s)}{Vapp\,(s)} = \frac{Kt}{LJS2+(LD+RJ)S+KtKs}$$

III. GENETIC ALGORITHM

Genetic Algorithms (GA.s) are a stochastic global search method that mimics the process of natural evolution. It is one of the methods used for optimization. John Holland formally introduced this method in the United States in the 1970at the University of Michigan. The continuing performance improvements of computational systems have made them attractive for some types of optimization.

The genetic algorithm starts with no knowledge of the correct solution and depends entirely on responses from its environment and evolution operators such as reproduction, crossover and mutation to arrive at the best solution. By starting at several independent points and searching in parallel, the algorithm avoids local minima and converging to sub optimal solutions. Genetic Algorithms are search and optimization techniques inspired by two biological principles namely the process of natural selection and the mechanics of natural genetics. GAs manipulates not just one potential solution to a problem but a collection of potential solutions. This is known as population. The potential solution in the population is called chromosomes. These chromosomes are the encoded representations of all the parameters of

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the solution. Each Chromosomes is compared to other chromosomes in the population and awarded beneficial characteristic to their offspring.

To encode better solutions, the GA will use genetic operators. or .evolution operators such as crossover and mutation for the creation of new chromosomes from the existing ones in the population. This is achieved by either merging the existing ones in the population or by modifying existing chromosomes. The selection mechanism for parent chromosomes takes the fitness of the parent into account. This will ensure that the better solution will have a higher chance to procreate and donate their There are three main stages of a genetic algorithm. These are known as *reproduction*, *crossover* and *mutation*.

The steps involved in creating and implementing a genetic algorithm:

1. Generate an initial, random population of individuals for a fixed size.

2. Evaluate their fitness.

3. Select the fittest members of the population.

4. Reproduce using a probabilistic method (e.g., roulette wheel).

5. Implement crossover operation on the reproduced chromosomes (choosing probabilistically both the crossover site and the mates.).

6. Execute mutation operation with low probability.

7. Repeat step 2 until a predefined convergence criterion is met.

The main objective function for implementing GA technique to PID controller can be decided on the basis of calculating ISE, IME , IAE .

Another function that is the *fitness function* is normally used to transform the objective function value into a measure of relative fitness, thus where *f* is the objective function, It transforms the value of the objective function to a non-negative number and *F* is the resulting relative fitness.

The best fitted value calculated is able to minimize the error which are introduced while controlling the speed of BLDC motor.

IV. IMPLIMENTATION OF GA TO PID CONTROLLER

The objective function is first calculated and then implemented to PID using MATLAB code. The various parameter used for calculation are population number, crossover method, selection method which are used to find the best solution for PID parameters.

The Kp, Kd,Kc are thus calculated from the data are implemented in the controller . The result from technique are plotted as graph.

The main steps involving the implementing the algorithm are

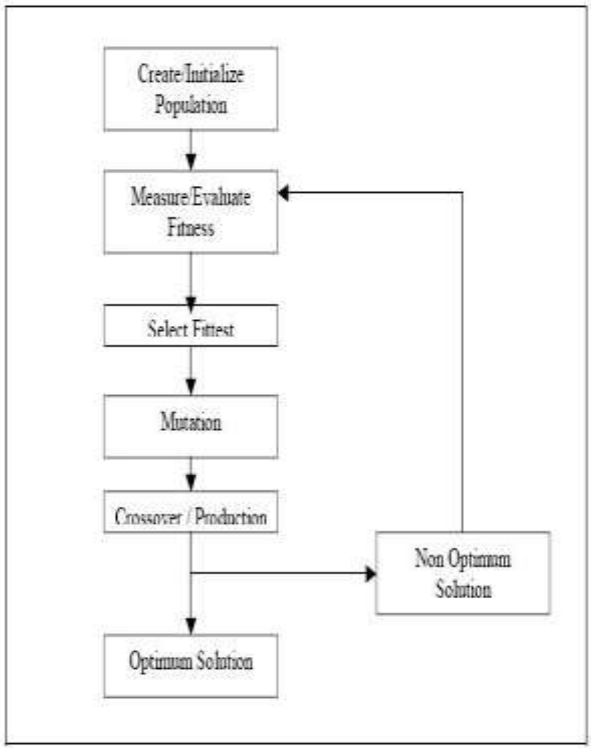

Fig. 1. Flow Chart of Genetic Algorithm

The values of controller parameters can be analysed by finding the value of integral square error, absolute error.

From output response, it can be observed that the PID parameter computation by Genetic algorithm shows the better performance in rise time, settling time , peak over shoot than ZNPID. The simulink model for the implementation of GA technique to PID controller in MATLAB is given below.

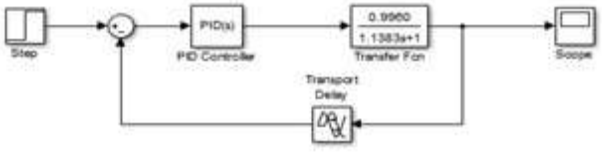

Fig. 2. Simulink Model of GA Tuned PID Controller

The closed loop control system can be represented in the figure.

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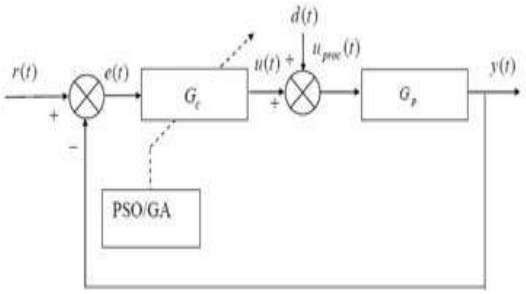

Fig. 3. Block Diagram of BLDC Motor

The results obtained from the data fed in the model are observed and compared to the conventional PID controller parameters.

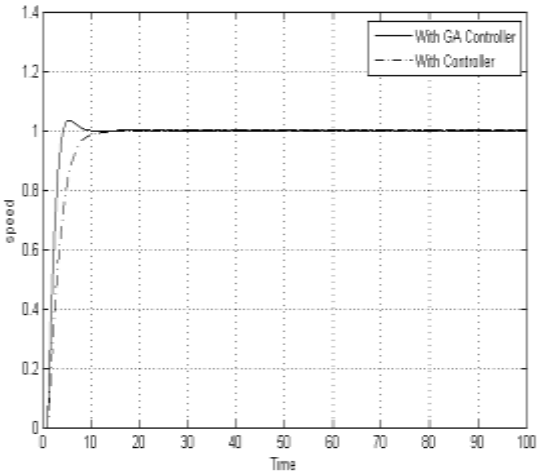

Fig. 4. Output Response with GA Tuned PID

From the output response obtained from model, we can make the performance table and analyze the result to obtain better speed control of the motor.

V. PERFORMANCE TABLE

Parameter	PID	GA TUNED PID
K_p	25.07	0.5380
K_i	0.1094	0.7843
K_d	0.02735	0.0130
T_r	0.0365	2.49
T_p	1.61	1.02
T_s	Infinite	5.59

VI. CONCLUSION

From the above table all the parameter values are apply to G.A the PID controller with DC motor is optimized. We can see from the data obtained that rise time, peak time , maximum overshoot have been controlled significantly. This result help in estimating the exact position control of BLDC motor.

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