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Implementation of PSO-Based Optimum Controller for Speed Control of BLDC Motor

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ABSTRACT: In this paper the implementation of PSO-based optimum Controller for Speed Control of Brushless Direct Current (BLDC) Motor is presented. Now BLDC Motor widely used for many industrial and vehicle applications because of their Long Operation Life, High Dynamic Response, High Efficiency, and better speed vs. torque Characteristics. And due to brushless design it is less noisy as compared to other options. This work presents the model construction of a brushless DC motor with MATLAB/Simulink to evaluate the performance of the BLDC motor controller with PID – PSO Control scheme. The model presented display the speed is regulated by PID Controller optimized by PSO technique. In variable-speed application of motor drives, utilization of BLDC motor has been widely used because the BLDC motors have Higher Speed Range, Higher Torque vs. Weight Ration and simpler structure. They also have better speed vs. torque characteristics and better dynamic response.

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Keywords: BLDC motor, PSO Algorithm, Modeling of BLDC Motor, PID – PSO Control of BLDC.

I. INTRODUCTION

Brushless DC Motors are particularly used for variety of industrial request like traction drive and electric vehicle request and heating ventilation system since of its higher good organization, high torque and low quantity. Positioning control is frequently required in BLDC motor. Due to over-weighing merits of this motor model is completed in order to improve the performance of the system. This paper presents the application, a variety of control schemes use and modeling of BLDC Motor in MATLAB/SIMULINK environment.

The intend of this effort is to design a speed controller of a BLDC motor by selection of PID parameters using bio-inspired optimization method i.e. Particle Swarm Optimization (PSO). Here, model of a BLDC motor is measured as a second order system for armature voltage control technique of speed control. In this work bio-inspired optimization system in controllers and their compensation over conventional technique is converse using MATLAB/Simulink. This Proposed optimization technique could be functional for higher order system as well to give enhanced system performance with minimum errors. The main plan is to be applicable PSO technique to design and tune parameters of PID controller to acquire an output with enhanced dynamic and static performance. The request of PSO to the PID controller imparts it the capability of tuning itself repeatedly in an on-line procedure while the request of optimization algorithm to the PID controller makes it to provide an optimum output by searching for the most excellent set of solution for the PID parameters. BLDC motor has straightforward structure and lower cost than other AC motors consequently it is used in variable-speed control of AC motor drives [1]. They have improved speed versus torque individuality, superior efficiency and enhanced dynamic response as compare to brushed motors and as well it delivers higher torque to the motor which make it useful where space and weight are critical factor. For torque production BLDC motor as well require position information which is obtain by with hall sensors.

The machine is have three phase stator with three phase distributed winding and the torque of the BLDC motor depends on the particular position of the back-EMF. Frequently the BLDCM has trapezoidal back-EMF waveform and stator is fed by rectangular stator existing and hypothetically it give a stable torque but the torque ripple exist due to EMF waveform imperfection, existing ripple and phase current commutation. The phase shift in EMF waveform consequences from variation in shapes of the slots, skew and attraction of BLDC Motor and each the higher than said factors are subjected for the design deliberation. This presents a BLDCM Model with the trapezoidal and sinusoidal back-EMF waveform. For preliminary and for given that proper commutation sequence to turn on the power devices in the inverter bridge the BLDC motor necessitate a rotor position sensor. The power devices are commutated following every sequentially 60 degrees rotation of rotor. As an alternative of commutating the armature current with brushes, electronic commutation is use for this motive it is an electronic motor. This eliminates the problems connected with the brush and the commutator arrangement, for example, spark and wearing out of the commutator brush understanding, in that way, production BLDC more rugged as compared to a dc motor.

BLDC motor has rotor position sensors controlled by the command signals, the command signal may be confidential as torque, voltage, and speed command and so on. The type of the BLDC motor is resolute by the structure of the control algorithms due to which there are two major types voltage source and existing source based drives. Enduring attraction synchronous machine with moreover sinusoidal or non-sinusoidal back-EMF waveforms is use by together voltage source and existing source based drive. Additional, this paper is organized as follows. In Section II, literature reviews are discussed. Section III introduces PSO and objective function used in the paper. And proposed methodology presented in Section IV with experimental results for speed control of DC motor in presence of dimension noise. And in the end conclusion of the paper is given.

II. LITERATURE REVIEW

This paper present a model that is base on fuzzy PID control of brushless DC motor speed control scheme. The reproduction specified its deviation and the rate of divergence modify of among the definite speed and the revolutionize of speed act as the input parameters of the fuzzy control conclusion engine, with the fuzzy theory PID parameters online is adaptively attuned and control system made reproduction experiment in MATLAB [1]. The intend of the SRM and its power converter, can consequence in a higher effectiveness to the equivalent induction machine operating at variable speed, the benefit that the Reluctance Motor and its drive are simpler in construction terms. Though, a quantity of parameters influences machine effectiveness, such as load torque, excitation of phases and firing angles useful to the machine power converter. In this paper, dissimilar control actions such as PI and Fuzzy controllers are implementing on reproduction in order to watch which strategy provide greatest good organization behavior [2].

In this paper the intelligent method for tuning a PID controller have been Compared. The dissimilar technique includes fuzzy logic, artificial neural network, adaptive neuro fuzzy supposition system and genetic algorithm. The controller tuned by the dissimilar method has been used for attentiveness control of a incessant stirred tank reactor (CSTR) which is a second regulate system with right half plane zero [3].

In the explanation reported in this paper, by with the data deliberate via the WSN, data

Transference and the fan's motor control are performing by the proposed ANFIS based WSN control method. This technique has great benefits, such as reducing the power consumption of the indoor space, improving the effectiveness of air conditioning and economy energy [4].

The main disadvantage of PI controllers reside in the determination of their parameters. Numerous design techniques of PI controllers were mention in literature. The majority used are the poles task method and the Ziegler-Nichols method, but their disadvantages lie in the necessary prior knowledge of the variety of parameters of the IM. In our work he has selected the GA optimization technique for the strength of mind of the optimal parameters of the use PI controller [5].

III. PROPOSED SOLUTION

The torque to the motor dimension ratio is higher makes it practical in the submission where space and weight are vital factor. BLDC motor utilizes entry sensor for identify rotor positing since the mechanical communicator is replace by electronic communicator. This makes drive system added multifaceted. The arrangement of the three phase BLDC Motor is dissimilar than the conventional DC motor. Three phase stator zigzag is on the stator and permanent magnet is on the rotor. The torque speed developed by the BLDC motor is influence by the back EMF. Frequently the BLDC motor has trapezoidal back EMF waveform and winding of the stator is provide by rectangular waveform stator existing.

And hypothetically BLDC produce a unvarying torque but torque is with ripple due to the information that EMF waveform imperfection.

The difficult coupling and non-linear performance of Brushless DC Motor system, the customary algorithms have a lot of performance disadvantages, above all poor precision, week speed tracking. Captivating into the individuality of BLDC into deliberation, an enhanced Particle Swarm Optimization algorithm is presented in this research, it is functional to the speed control of the Brushless Motor servo system. Initially, a Particle Swarm Optimization (PSO) algorithm, which is a bird food base searching algorithm, is introduced. Secondly, the algorithm is use to judgment the PID coefficient for optimum control of BLDC motor.

Lastly, the model of the BLDC motor servo system is constructed in MATLAB/Simulink. PSO based High performance, simpler PID controller for Brushless DC Motors control system; get better the performance of the BLDC motor speed regulation. Through the PSO algorithm a lot bigger Solution Space was searched and discover and optimum solution of the problem of identify parameters of PID controller PSO algorithm is a narrative random optimization scheme based on swarm intelligence, which has additional influential ability of global optimization and are particularly useful for parameter optimization in incessant, multi-dimensional search spaces.

Initially, this work proposes an enhanced Particle Swarm Optimization algorithm that is practical to PID coefficient setting. Reproduction results show that the algorithm is distinctiveness by quick response and stability, and robustness.

The BLDC motor servo system is constructed in MATLAB/Simulink. PSO base High performance, simpler PID controller for Brushless DC Motors control system, get better the presentation of the BLDC motor speed regulation. With the PSO algorithm a great deal better explanation Space was searched and discover and optimum explanation of the problem of identify parameters of PID controller.

The PSO Algorithm

PSO is a multi-agent parallel search technique. Particles are entitled through fly during the multi-dimensional search space. At any exacting immediate each particle has a position and velocity. The position vectors of particles with high opinion to the origin of the search space represent a trail answer of the search problem. At the opening a population of particles is initialized with random positions noticeable by the vectors i X and random velocities i V. The population of such particles is called swarm S. A neighborhood relation N is distinct in the swarm. N decides whether two particles Pi and Pj are neighbor or not. The equations are obtainable for the d-th dimension of the position and velocity of i-th particle. Together simulation models and statistical model can be use for enlightenment and prediction of the scientific phenomena. Simulation as a technique of scientific investigate is plays a vital role these days.

The optimization techniques are introduced for the function of tuning the parameters to search for the best resolution by minimizing the purpose function. To get the objective the connected characteristics like rise time, maximum overshoot, settling time, gain margin, phase margin are measured and compare for dissimilar optimization methods. A set of performance indicator may be use as a design tool to assess tuning method.

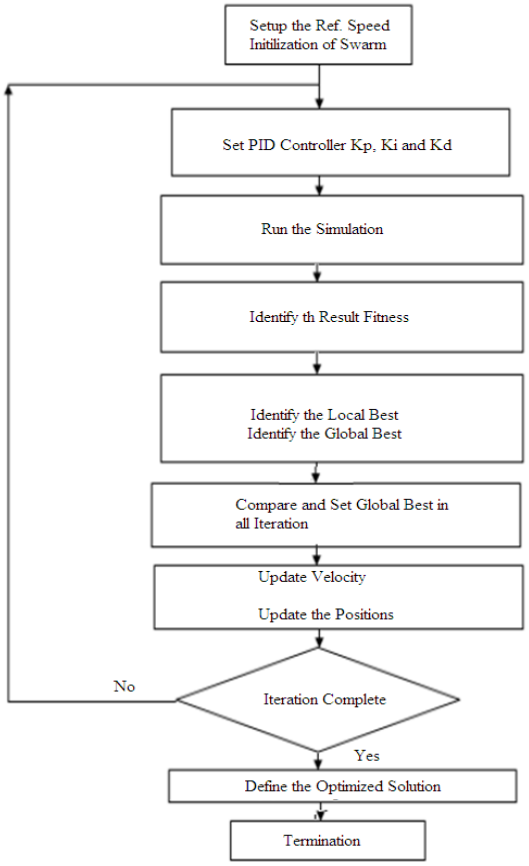

Fig. 1. PSO Algorithm for Optimum Tuning of BLDC Motor Controller.

X is representing position.
V represents the velocity.
w represents the inertia.
N represent the total swarm size
d represents the dimension (d=2 / d=3).
t iterations(generations),
c1,c2 Acceleration constant, between 0 and 1.

$V^t_{i,m}$ Velocity of particle i at iteration t, dimension m,
$X^t_{i,m}$ Current position of particle i at iterations,
$Pbest_i$ Best previous position of the i-th particle,
Gbest Best particle among all the particles.
Velocity is updated with following equation.

$$V_{i,m}^{t+1} = w\, V_{i,m}^{t} + C_1\, rand(\ )\left(Pbest_{i,m} - X_{i,m}^{t}\right) + C_2\, rand(\ )\left(Gbest_m - X_{i,m}^{t}\right) \qquad Eq.1$$

Position is updated with following equation.

$$X_{i,m}^{t+1} = X_{i,m}^{t} + V_{i,m}^{t+1} \qquad Eq.2$$

IV. SIMULINK MODEL

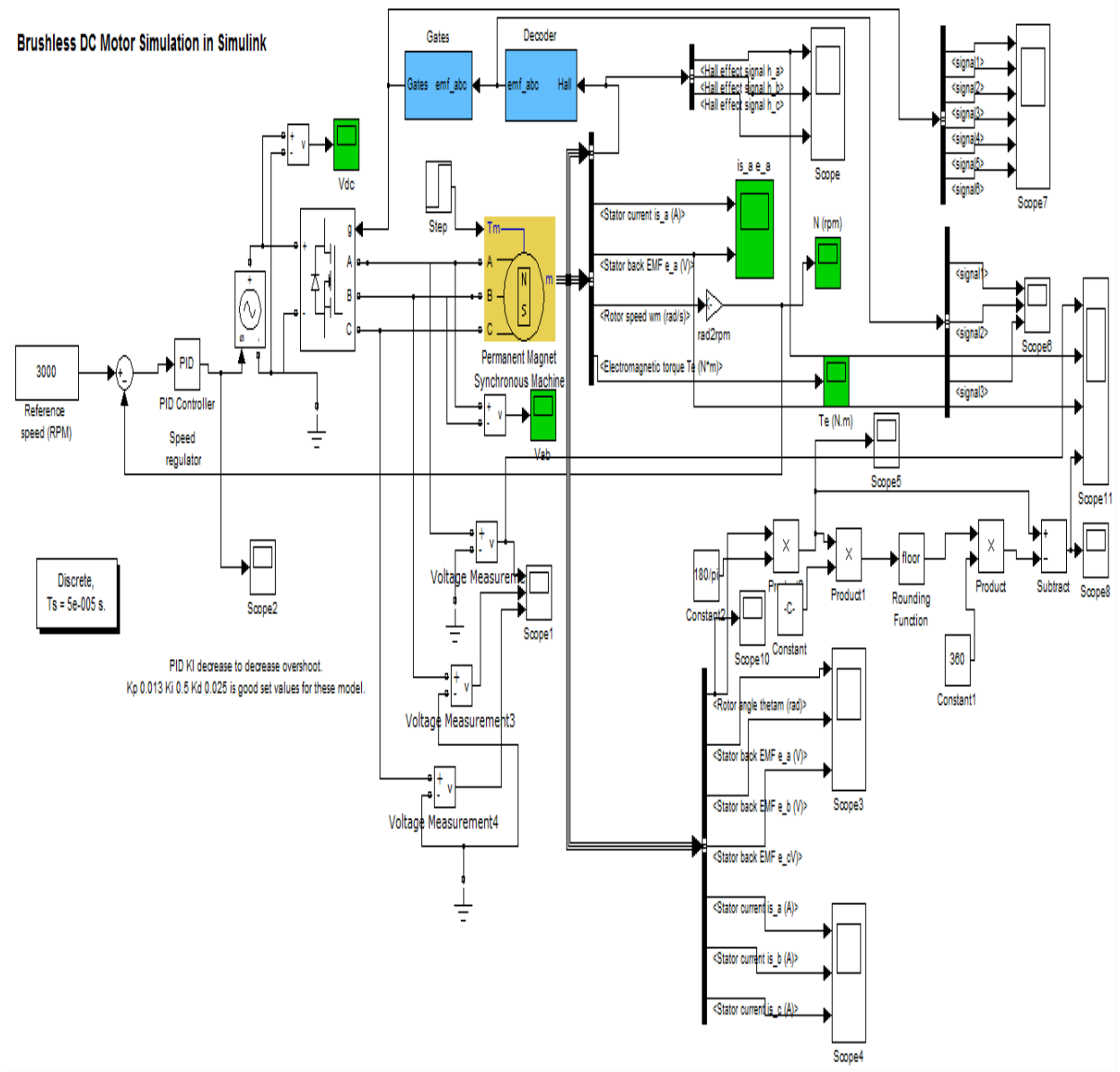

Fig. 2. Simulink Model of BLDC Motor with PID–PSO.

The BLDC motor is developed with Permanent magnet synchronous three phase motor. The three windings of the BLDC motor is fed by a six arm three phase inverter. The inverter is controlled by the hall sensor signal output from the BLDC motor. The BLDC motor output three hall sensor signals ha, hb and hc. The inverter is energized by the controlled DC voltage source. The DC controlled source is controlled by the PID controller. The reference to the PID controller is 3000 RPM and the output speed of the BLDC motor is fed to the difference circuit. This difference is considered as the error signal by the PID controller. Fig. 2 shows the simulink model of PSO–PID speed controller. Fig. 3 show the position of swarm as Kp, Ki and fitness function for 100 iteration simulation. And table also shows the optimized solution in the simulation, with different iteration and bird.

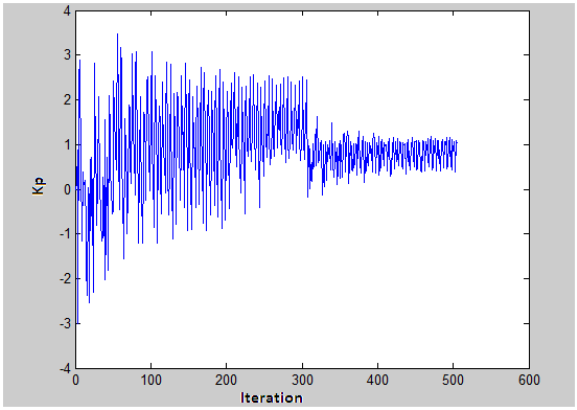

Fig. 3. Kp Iteration of swarm for 100 generations.

The figures show the variations in the value of the Kp and Ki as iteration progresses. In this simulation we have used a swarm as a group of 5 birds, and the iteration it for 100 times. Hence the model is executed by 5X100 times, that is 500. The both figure show the start time random values of the parameters is optimized in the end at the final iteration. The simulation of final iteration for the speed is shown in the fig. 5.

The simulation of the model is run for 500 times by the PSO code. We have used swarm size of 5 bird and 100 steps and this makes total 500. The fig 3 and fig 4 shows the value of Kp and Kd or position update during the PSO simulation.

Use of PSO for the resolution of problems connected in the BLDC motor control area is a fairly important, since inference of parameter of controller is significant task. The output of the motor is feed to the PSO block and novel parameter is optional by the PSO technique. And then subsequently output is yet again feed to the PSO block and many iteration of this cycle is perform and to conclude in the end of every iterations best parameter is acknowledged as optimized parameters.

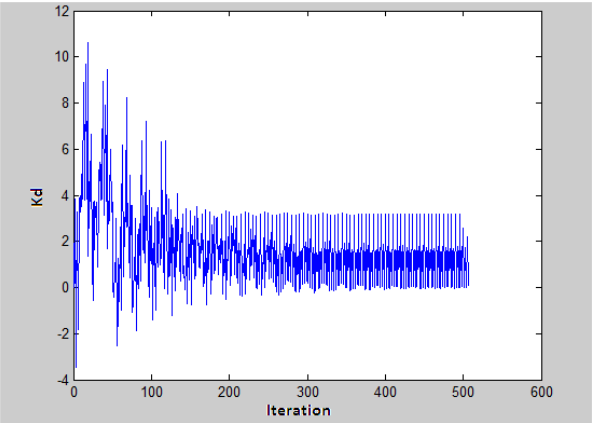

Fig. 4. K_d Iteration of swarm for 100 generations.

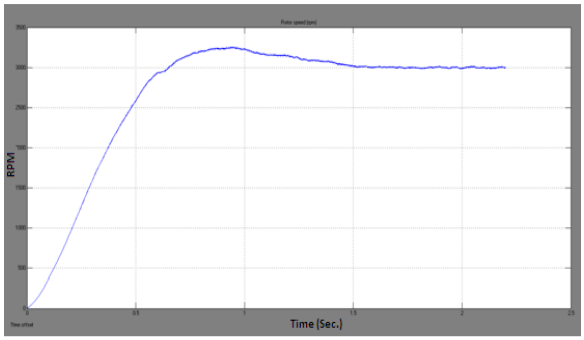

Fig. 5. Speed - Simulation of the BLDC Motor.

The fig. 5 shows the speed simulation of the BLDC motor.

Table 1: Summery of Simulation parameters.

S. No.	Variable	Value
1.	Size of the swarm	5
2.	bird_step	100
3.	dim	2
4.	c2 =1.2	1.2
5.	c1 = 1.5	1.5
6.	w =0.9	0.9
7.	Kp (it = 0)	Random
8.	Ki (it = 0)	Random
9.	Kd (it = 0)	Random
10.	Kp (it = final)	1.119
11.	Ki (it = final)	0.924
12.	Kd (it = final)	0.5

V. CONCLUSION

The primary part of this work is concerned growth of six step inverter and its connection with the BLDC motor. In this research the development of PID controller for the BLDC motor is accepted out. For the optimization of the PID controller is done through the assist of PSO optimization algorithm. The real-world parameters of the BLDC motor is used for the confirmation of the operational of the BL DC motor with the PID controller. An easy model of the BLDC motor is developed with Simulink motor block, and then it is controlled with the PID controller primary and then the optimization of the PID parameters is complete with the assist of PSO algorithm. The speed control of the BLDC motor is implemented with hysteresis band control method.

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