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Comparison of Different algorithm for Speed Control of Brushless D.C Motor Using Matlab Simulink

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Abstract:-
Brushless DC Motors have a permanent magnet rotor and the stator winding are wound such that the back electromotive force (EMF) is trapezoidal. The motor posses high Torque/weight ratio, operate at very high speed, very compact & electronically controlled. In this paper, we have to use three algorithms ZN, GA & PSO respectively. On the basis of performance of these three techniques, PSO have high efficiency as compare to other two techniques Error rate in PSO algorithm is 1.395 which is less than ZN algorithm & GA algorithm.

Key Words:-
BLDC (Brushless Dc Motor), PSO (Particle Swarm Optimization), GA (Generic Algorithm), ZN (Zeigler Nicholas), PID (Proportional Integral Derivative), IAE (Integral Absolute Error).

1. Introduction

In variable speed control of ac motor drives, utilization of BLDC motor has been widely used because the BLDC motor has simpler structure and lower cost than other ac motors. They better speed verses torque characteristics, high efficiency, and better dynamic response and also the torque delivered to the motor size is higher making it useful where space and weight are the critical factor. BLDCM also need position information for the torque producing and this information is obtained by using hall sensors it increases the machine size and rotor inertia it also need make drive system complex.

A three phase BLDC motor has three phase stator winding on the stator and permanent magnet rotor. The torque developed in BLDC motor is affected by waveform of back e.m.f . Usually the BLDC motor has trapezoidal back e.m.f waveform and stator is fed by Rectangular stator current and theoretically it gives a constant torque but the toque ripple exist due to the e.m.f imperfection , current ripple and phase current commutation.

Due to the high torque to volume ratio of BLDCM, it dominates for High Performance Drives (HPD) applications, such as robotics, guided manipulation and dynamic actuation, the precise rotor movement over a period of time must be achieved. A multi-robot system performing a complementing function must have the end effectors move about the space of operation according to a pre-selected time tagged trajectory. Also, the Brushless dc motor, as the name implies, has no brushes. This is an essential requirement for several industrial applications such as airplane actuation, food and chemical industries. This must be achieved even when the system loads, inertia and parameters are varying. To do this, the speed control strategy must be adaptive, robust, accurate, and simple to implement [3].

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. Even if a model can be obtained for the system under control, unknown conditions such as saturation, disturbances, parameter drifts, and noise may be impossible to model with acceptable accuracy. For most of the basic electric drives applications, these unknown conditions in addition to the system nonlinearities can be ignored, but it may lead to unacceptable tracking performance. High accuracy is not usually imperative [4]. Some adaptive control techniques, such as the variable structure and the self-tuning, do not need a model for system dynamics. The dynamic model is, rather, developed based on the on-line input/output response of the system under control [5].

II. Mathematical Modelling

Three-phase and two-pole BLDC motor is studied. 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 [18]:

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

$$v_{emf} = K_{b.}\omega(t)$$

$$T(t) = K_{t.}i(t)$$

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

where $v_{app}(t)$ is the applied voltage, $\omega(t)$ is the motor speed, *L* is the inductance of the stator, *i(t)* is the current of the circuit, *R* is the resistance of the stator, $v_{emf}(t)$ is the back electromotive force, *T* is the torque of motor, D is the viscous coefficient, *J* is the moment of inertia, K_t is the motor torque constant, and K_b is the back electromotive force constant.

Fig1. shows the block diagram of the BLDC motor. From the characteristic equations of the BLDC motor, the transfer function of speed model is obtained

$$\frac{\omega(s)}{v_{app}(s)} = \frac{K_t}{L.J.S^2 + (\text{LD}+\text{RJ})\text{S}+K_tK_b}$$

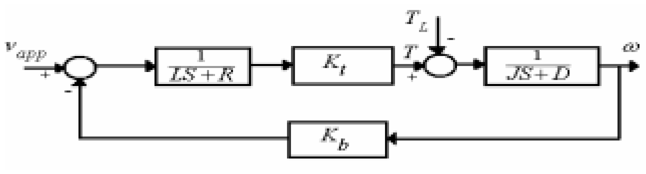

Fig 1. Transfer function block diagram of BLDC

The parameters of the motor used for simulation are as follows: 2hp, 230 volts, 8.5 amperes, 1500 rpm, Ra=2.45 ohm, La=0.035H, Kb=1.2 volt/(rad/sec), J=0.022Kg-m2/rad, B=0.5*10^-3 N-m/(rad/sec).

III. Controller Design

There are basically three algorithms used for speed control of D.C Brushless motor. & simulink design is given by fig 2.

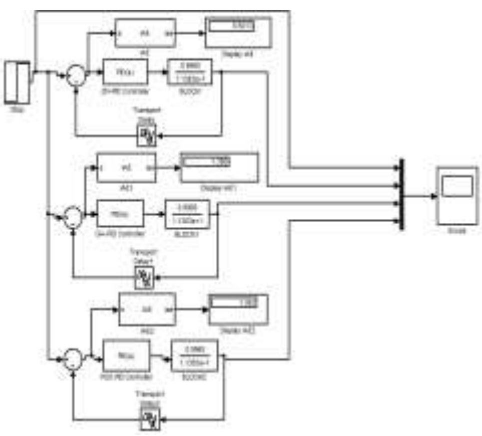

Fig 2. Simulink Design of DC Brushless Motor

Three algorithms are used to control D.C Brushless motor [8]

1. PSO (Particle Swarm Optimization)
2. GA (Generic Algorithm)
3. ZN (Zeigler Nicholas)

IV Simulation Results

Simulation results are given by table 7.1 & 7.2 respectively. The performance is measured in terms of proportional constant, settling time ,maximum peak overshoot & intergal absolute error .

Parameter	Value
Swarm size S_s	20
Maximum Velocity (Vmax)	1
Coginitive Acceleration (c_1)	2.5
Social Acceleration (c_2)	1.6

Table 1. PSO Parameter setting

For PSO algorithm, we have to use following parameter swarm size, maximum velocity, cognitive acceleration, social acceleration.

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

Table 2. GA Parameter Setting

The GA parameters in Table 7.2 were kept constant for all the simulation experiments and follow standard implementations [4].As a consequence of their stochastic nature, the PSO and the GA yields different controller parameter solutions for each trial. For this reason both optimization methods were each run for ten trials and the average values of these ten trials was then used as the controller tuning parameters.

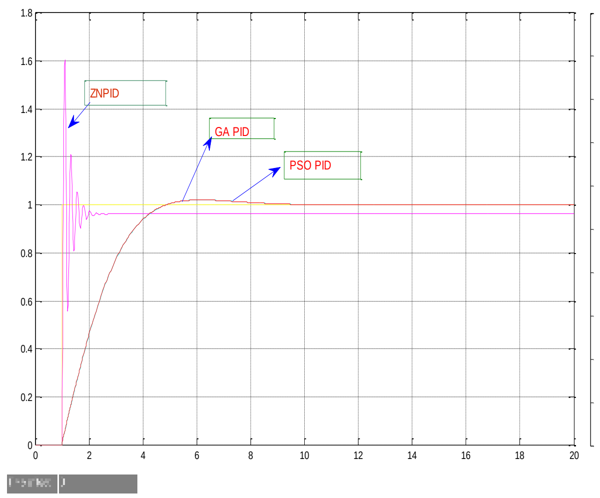

Fig3 Cumulative Step Response of BLDC motor using ZNPID, GA PID, PSO PID

Parameter	ZN PID	GA TUNED PID	PSO TUNED PID
K_p	25.07	0.5380	0.5425
K_i	0.1094	0.7843	0.7871
K_d	0.02735	0.0130	0.0145
T_r	0.0365	2.49	2.49
T_p	1.61	1.02	1.02
T_s	infinite	5.59	5.56
M_p	60.9	2.09	2.08
IAE	3.269	1.401	1.395

Table 3. Performance Table

From Table 7.3, we can see that PSO based controller has a significant improvement over the Genetic Algorithm and Zieglar Nicholas based PID controller. On average the percentage improvement of PSO controller against GA controller in the system output performance based on overshoot. However the set back is that it is inferior when it is compared to the rise time and settling time. Finally the improvement has implication on the efficiency of the brushless motor.

V Conclusion

In conclusion the performance table as shown in table 3 has showed that the designed PID with PSO has much faster response than using the classic methods. . There are many steps and also trial and error in getting the PID values before you can narrow down in getting close to the optimized values. An optimized algorithm was implemented in the system to see and study how the system response is. However the PSO designed PID is much better in terms of the rise time and the settling time.

References

[1] Zhang. Y, Akujuobi .C.M, Ali.W.H, Tolliver.C.L, and Shieh.L.S,“ Load disturbance resistance speed controller design for permanent magnet synchronous motor,” *IEEE Trans. Ind. Electron., vol. 53, no. 4, pp. 1198–1207, Aug. 2006.*

[2] Concari.C,Torni.F,“ Sensor less control of BLDC motor at Low Speed based on differential bemf measurement , *IEEE, Conference on energy conversion congress & exposition, pp. 1772-1777, sept.2010*

[3] Rahman. M.A," Special section on Permanent magnet motor drives; Guest editorial," *IEEE, Trans. on Industrial Electronics, vol. 43, no. 2, pp. 245, 1996.*

[4] Yu.G.R, Hwang.R.C,” Optimal PID Speed control of BLDC motor lqr approach”, *IEEE, Conference on system, man & cybernetics, vol.1, pp. 473-478, Oct.2004.*

[5] Chan.C.C, Jiang.J.Z. Chen.G.H, Wang.X.Y and Chau.K.T, “ A novel poly phase multi pole square wave permanent magnet motor drive for electric vehicles”, *IEEE, Transactions on Industry Applications, vol. 30, no. 5, pp. 1258-1266, 1994.*

[6] Meireles. M.R.G, Almeida .P.E.M and Simões.M.G, “A Comprehensive Review for Industrial Applicability of Artificial Neural Networks*”, IEEE, Trans. on Ind. Electron. vol. 50, no. 3, pp. 585-601, Jun. 2003.*

[7] Weerasooriya .S and Sharkawi. M. A. El," Identification and control of a dc motor using back-propagation neural Network”, *IEEE, Transaction on Energy Conversion, pp 663-669, December, 1991.*

[8] Pillay. P and Krishnan. R, “Application Characteristics of Permanent Magnet Synchronous and Brushless dc Motors for Servo Drives,” *IEEE Trans. Ind. Appl., vol. 27, no.5, pp. 986-996 Sept./Oct. 1991.*

[9] Cheng. M , Chau. K.T, and Chan. C.C, “Design and analysis of a new doubly salient

permanent magnet motor," *IEEE Trans. Magn., vol. 37, pp. 3012–3020, July 2001.*

[10] Ganesh.C, Prabhu.M, Rajalakshmi. M,Sumathi.G, Bhola.V, Patnaik.S.K," ANN Based PID Controlled Brushless dc Drive System", *Proc.of int. conf on IEEE, 2011*

[11] Chen. Z, Tomita. M, Doki. S, and Okuma. S, "New adaptive sliding observers for position and velocity sensorless controls of brushless DC motors, " *IEEE Trans. Ind. Electron., vol. 47, no. 3, pp. 582-591, June2000.*