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Speed Response Optimisation of A Bldc Motor Drive with Ga-Based Classical Controller Tunning

Upama Das, Pabitra Kumar Biswas

Abstract*: *The paper addresses the improvement of performance and quality of engines such as BLDC. Better performance, lower maintenance, higher cost, quiet activity, and compact design define a DC motor brushless drive. PI operator, PID controller, fuzzy logic, genetic algorithms, neural networks, PWM power, and less sensor command, there are several methods for regulating the speed of the motor. The GA-based PI and GA-based PID controllers are used for the speed control of BLDC motor. These motors are used in applications such as automobiles, aviation, health, instrumentation, machine tools, robots, and actuation, because of their desirable electrical and mechanical properties. The main gain of the recommended technique is that there is no need for an accurate model of the controlled structure, so it is useful in many industrial processes that do not have an apparent or sophisticated design. Therefore, this method allows determining the best PID values for a given overrun, a rising period, a settling time, and steady-state failure. The algorithm works on three essential selection, crossover, and mutation genetic operators. GA has many variations, such as Real coded GA, Binary coded GA, depending on the forms of these operators. Such variables have a significant influence on the control system's reliability and efficiency. This paper focuses on binary-coded GA & considers crossover quality, PID controller mutation, and computational analysis were conducted. The transition mechanism was studied with MATLAB in the process. With the GA-based PI and PID operator, the BLDC motor is modeled, and the simulation tests are collected. The results obtained through the application of the GA-based algorithm are efficient and satisfy the control characteristics defined.

Keywords*: *Brushless DC motor, Genetic algorithm, closed-loop speed control, MATLAB simulation.

I. INTRODUCTION

In industrial applications as well as other purpose-built applications, high-performance electric motor drives are very relevant. In general, there is a more exceptional adaptive approach for better performance of an electric motor drive system. DC motors are commonly preferred among all motors in various variable speed functions requiring high control specifications such as electric vehicles, steel rolling mills, electrical cranes, high-precision digital tools, and robotics. This is because of its quick, reliable, and wide variety of control features. The DC motor frequency is directly proportional to the voltage of the armature and vice versa to the magnetic field flux. The armature voltage and field current regulation can alter the frequency of the DC motor. The BLDC motor is almost the same as DC motor, which typically finds applications in household goods, locomotive, spaceship, medical instruments, automatic equipment, and robots [9]. Depending on the back waveform of the EMF, these motors are classified into two types. PMBLDC engines have EMF and quasi-rectangular current waveform trapezoidal back. A BLDC motor is referred to as a "synchronous" type, as the stator and rotor produced magnetic fields rotate at the same speed. Another drawback of this system is that BLDC engines do not undergo the usual "slip" of induction engines. Instead of brushes, the BLDC motor is electrically operated via control levers. The BLDC motor has numerous benefits compared to other DC and AC motors: better productivity, consistency, lesser auditory sound, reduced and lightweight, higher prominent outcome, better speed versus torque characteristics, high-speed operation, longer life. A BLDC motor is identical to a DC shunt motor in which permanent magnet replaces static field winding. Because of their versatility and low cost, DC Motor plays a crucial role in testing, laboratory experiments, and electrical control, high-speed device applications in industry. The frequency of the DC motor can, therefore, be regulated by adjusting the flux/pole, the resistance of the armature, and the voltage applied. Because of its simple structure and excellent performance, one of the most common controllers used for speed control of BLDC motors is the PID controller. The general configuration of BLDC motor is given in the figure-1.

Additionally, the PID controller's parameters can be easily changed with technological advances without the need to modify any equipment. Nevertheless, the PID controller's output depends on the model's reliability and device parameters. The managed structures are generally non-linear in operation, and their precise mathematical models are therefore not usable. Furthermore, with time and operating conditions, device parameters can differ. The techniques for changing the parameters of the system are, therefore, of great importance. The PID controller's parameter setting is to specify the parameters that match the managed system's necessary characteristics.

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* Correspondence Author
Upama Das*, Pursuing, Ph.D. Department of Electrical and Electronics Engineering, National Institute of Technology, Mizoram, India.
Pabitra Kumar Biswas, HOD and Assistant Professor, Electrical Engineering, National Institute of Technology, Mizoram, India.

The PID methodology is the best-known type for traditional tuning techniques. It is stable against the process model's volatility and is suitable for many industrial applications. It does not provide perfect control, though; as it generates a significant device reaction overshoot. Many smart approaches have been projected to recover the operation of modern tuning methods. These methods are based on the genetic algorithm (GA), the optimization of iterative feedback (IFT), the optimization of particle swarm (PSO), and the optimization of fruit fly (FOA). Such approaches are forms for performance optimization in which there are various analytical parameters that measure the effectiveness of the tuning processes. Due to the different objective features, the best value of the PID controller parameters obtained in each method is different, and therefore the regulated device response is different [4].

Therefore, although these methods are quite beautiful, it is impossible to achieve the optimum result of the controlled system. This paper introduces a new method for constructing a BLDC motor speed controller by choosing PID parameters using GA to illustrate GA performance. The effects of this system were contrasted with the primary PID controller. Each time the best controller is tested for the process utilizing genetic algorithms to achieve the controller tuning test. This paper aims to display the coded binary GA & find crossover meaning, PID controller mutation. The block diagram of closed loop BLDCM with GA has been shown in figure-2.

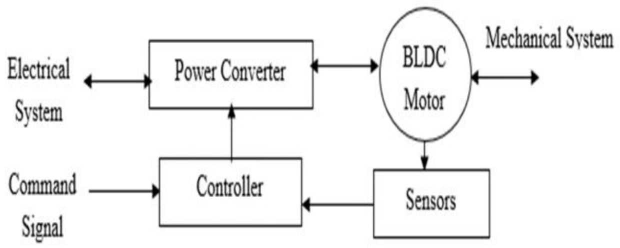

Figure-1: General presentation of BLDCM

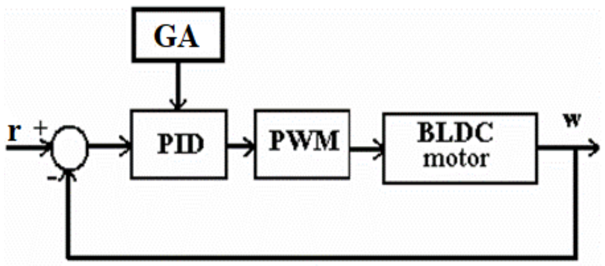

Figure-2: Block diagram representation of GA-based speed control of BLDCM Drive

II. CONSTRUCTION OF BLDCM

Unlike any other spinning electrical unit, the BLDC motor also has a similar principle of construction and operation. The first one is a rotor, and the second one is a stator as shown in figure-3. The other essential parts are the winding, and the field magnet placed respectively on the stator and rotor. Sometimes named permanent magnets as a rotor magnet. The brushless DC motor has two specific rotor design restrictions, the first being the configuration of the internal rotor and the second being the layout of the outer rotor. In constructing an inner rotor, the rotor magnets are enclosed by the winding of the stator and are installed in the motor's casing. One of the most beneficial points for the design of the internal rotor is its capacity to dissipate heat generated within the winding of the stator. This type of engine is capable of producing more torque thanks to the correct heat dissipation properties. For this purpose, many BLDC engines are of the form of an inner rotor layout. The rotor magnet acts as an insulator between the stator winding and the engine yokes, so that heat generated inside the stator winding is not homogeneously dissipated throughout the motor. Because of the stator position winding the BLDC motor's external rotor layout works at low voltage and current. This means that its calculated voltage and rating current are lower than the BLDC motor's comparable inner rotor configuration ranking. This form of rotor's primary strength is its relative low cogging torque. These motors comprise of layered steel laminations and windings located in the stator slots formed along the internal perimeter. Many brushless DC motors have three-phase star stator windings. To produce such type of winding, all of these windings are accumulated together with separate intertwined coils. The windings are spread above the exterior stator field to have an even number of poles. The BLDC motor utilizes electromagnetic concepts to transform electrical energy into mechanical energy. In all-electric motors, the energy conversion process is essentially the same. The motor activity is grounded on the attraction and repulsion of magnetic poles. The process begins in the three-phase motor when the current passes over any stator winding produce a magnetic field that absorbs the opposite pole's nearest permanent magnet. When the current moves to an adjacent winding, the rotor must switch. Loading each winding can allow the rotor to match the spinning ground.

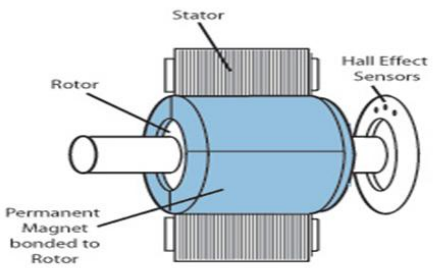

Figure-3: Constructional Review of BLDC motor

III. MODELING OF THE BLDC MOTOR

The following figure-4 defines the basic BLDC engine and inverter building blocks resulting in a device delivering a linear speed-torque profile comparable to the traditional DC engine. Its stator has star-connected windings, and fields are mounted on the rotor. During stator stage windings, trapezoidal EMFs are caused when the motor is worked at a certain rpm.

The AC supply is provided to stator windings using the currently regulated voltage source inverter via electronic commutator resulting in constant torque production by the motor. The modeling of the BLDC motor and a synchronous machine is the same. Therefore, magnetic flux saturation is characteristic of this type of engine. Like any conventional three-phase engine, the voltage of the BLDC motor's armature winding is presented as follows[1].

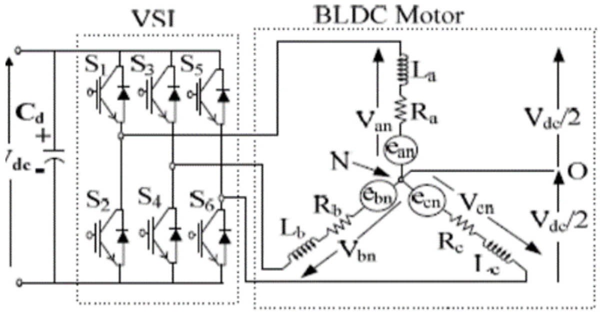

Figure-4: BLDC Motor supplied by DC voltage via an Inverter System

$$V_{an}= R_s +L\frac{di_a}{dt}+ M\frac{di_b}{dt}+ M\frac{di_c}{dt}+ e_a \quad (1)$$

$$V_{bn}= R_s +L\frac{di_b}{dt}+ M\frac{di_c}{dt}+ M\frac{di_a}{dt}+ e_b \quad (2)$$

$$V_{cn}= R_s +L\frac{di_c}{dt}+ M\frac{di_b}{dt}+ M\frac{di_a}{dt}+ e_c \quad (3)$$

Where, L= armature self-inductance [H]
M= armature mutual inductance [H]
R= armature resistance [Ω]
V_{an}, V_{bn} and V_{cn} are terminal phase voltages [V]
i_a, i_b and i_c Are motor input current [A]
e_a , e_b and e_c are motor back-EMF [V]

These three equations can be interpreted as equation-4.

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \begin{bmatrix} R_s & 0 & 0 \\ 0 & R_s & 0 \\ 0 & 0 & R_s \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \begin{bmatrix} L & M & M \\ M & L & M \\ M & M & L \end{bmatrix} P \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \begin{bmatrix} e_a \\ e_b \\ e_c \end{bmatrix} \quad (4)$$

Equation1,2 and 3 can be written as follows:

$$V_{an}= R_s\, i_a+L_s\, \frac{di_a}{dt}+\ e_c \quad (5)$$

$$V_{bn}= R_s\, i_b+L_s\, \frac{di_b}{dt}+\ e_b \quad (6)$$

$$V_{cn}= R_s\, i_c+L_s\, \frac{di_c}{dt}+\ e_c \quad (7)$$

$$\begin{bmatrix} \frac{di_a}{dt} \\ \frac{di_b}{dt} \\ \frac{di_c}{dt} \end{bmatrix} = \left\{ \begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} - \begin{bmatrix} R_s & 0 & 0 \\ 0 & R_s & 0 \\ 0 & 0 & R_s \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} - \begin{bmatrix} e_a \\ e_b \\ e_c \end{bmatrix} \right\} \frac{1}{L_s} \quad (8)$$

By solving these three differential equations by using the Runga Kutta approach, the values of the Ia, Ib, and Ic values can be obtained. The cumulative torque value is as follows.

$$e_a= K_a\, w_r$$

$$P_m= (e_a\, i_a+e_b\, i_b+e_c\, i_c) \quad (9)$$

$$T_m=\frac{P_m}{w_m}=\frac{(e_a i_a+e_b i_b+e_b i_b)}{w_r}\frac{P}{2} \quad (10)$$

$$T_e=\frac{(k_a i_a+k i_b+k_c i_c)w_r}{w_r}\frac{P}{2} \quad (11)$$

$$T_e=\frac{P(k_a i_a+k i_b+k_c i_c)}{2} \quad (12)$$

The equations of speed and torque are shown below:

$$T_e\text{-}T_l=\frac{Jdw_{rm}}{dt}+Bw_{rm} \quad (13)$$

$$\frac{Jdw_r}{\frac{P}{2}dt}+\frac{Bw_m}{\frac{P}{2}}+T_l=T_e \quad (14)$$

$$\frac{dw_r}{dt}=\frac{P}{2J}(T_e\text{-}T_l\text{-}\frac{2B}{P}w_r) \quad (15)$$

IV. GENETIC ALGORITHM

The design of a BLDC motor is typically a multi-objective design issue with multiple variables and restrictions. The problem of optimization is described by three measures. Next, the factor of optimization, i.e., the mathematical parameters of the motor, is specified. Furthermore, the goal function and the restrictions are formulated, and an approximation solver is ultimately used to determine the motor's optimum geometry. The most crucial part of optimization is the design of objective function, which is usually a mixture of power loss, expense, and quantity. Certain parameters may be regarded in some situations, such as minimal cogging force, harmonic, friction, flux leakage, and overall robustness. Due to mechanical (nominal torque and speed) and electrical (available voltage level) specifications in addition to price, output, and volume limits, restrictions are placed on the issue. The optimization methodology can be either a non-linear programming method such as quadratic sequential programming or a search-based approach such as genetic algorithms (GAs).

In Genetic algorithms, the search space components are binary twines or further primary forms sets. This is a computational based search strategy based on biological organisms ' genetic processes that have evolved and flourished in evolving highly competitive environments. Over the past decade, the applications of such algorithms to address optimization issues in the BLDC motor drive system have seen many promising developments. Genetic algorithms (GAs) are a fast, efficient, and accurate solution for optimizing hard problems. As the real-time controller's sophistication grows, the use of genetic algorithms (GAs) has expanded in more than equal measure.

The quest for an ideal condition is one of the most fundamental principles of our world. Optimization is the method of changing system outputs or parameters, numerical processes to achieve minimum or maximum efficiency. The specific function called cost, objective, or fitness is the input to the optimization process.

Optimization is a primary tool for solving unsolvable or complicated issues. Algorithms for optimization can be divided into five categories. The processes influence the performance in trial and error optimization without understanding the limitations, which is responsible for producing the product. A mathematical formula defines the optimal goal variable. Single dimensional optimization uses a single parameter, while a multi-dimensional solution involves a problem with more than one factor.

As the number of dimensions grows, it becomes challenging to automate the system. Dynamic optimization depends on time, while static optimization depends on distance. Through converting parameters, a restricted optimization problem can be transformed into an unconstrained one. Several algorithms for optimization are built-in their original form. Global optimization's goal is to find the global equilibrium, i.e., world limit or objective function zero. In order to find appropriate conditions or models of parts or projects to be put into action by people or computers, modeling challenges are used.

This algorithm's workability is grounded on Darwinian's most fitting existence concept. It includes terms like a chromosome, gene, sample set, fitness, breeding, mutation, and selection. The first step is to set some solutions, and they are called population. These populations were considered, and a new society is formed to inspire the prospect of bettering the new population than the former. In contrast, solutions are chosen for new solutions, i.e., children, according to their health. The cycle above is replicated until some requirement is met [3]. The primary steps of genetic algorithm (GA) are shown with a suitable flowchart in figure-5.

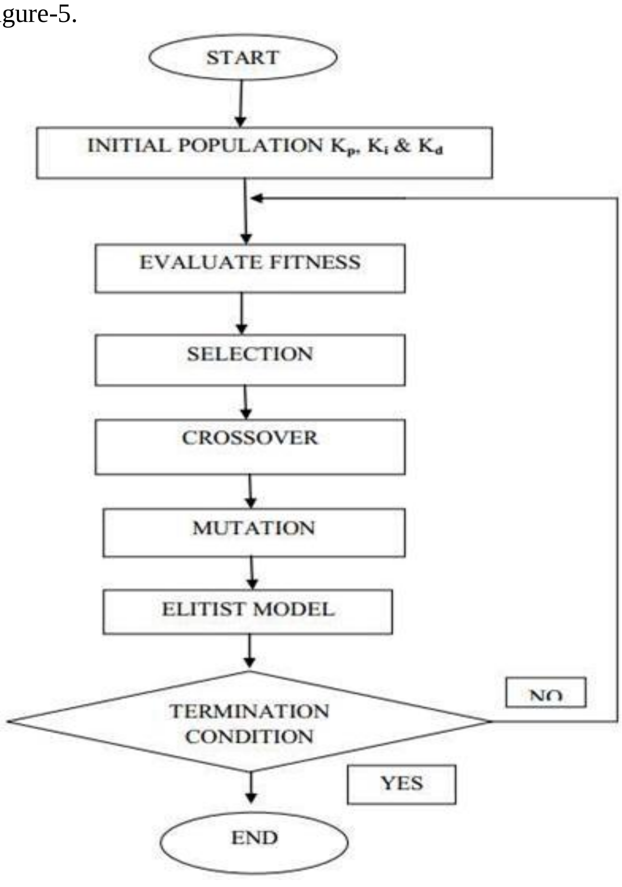

Figure-5: Steps of Genetic algorithm

1. Code the parameter: Genetic algorithm (GA) encoding methods are specific problems that change the problem clarification into chromosomes. Binary encoding, permutation encoding, quality encoding, and graph encoding are the name of different encoding techniques.
2. The initialization of the population: In this step, an arbitrary population of the PID controller constant chromosomes is generated, where correct solutions are first produced within the boundaries that have been defined to avoid too many constants which may contribute to an unstable system.
3. Evaluate the fitness of each member: In this step the system assesses the health of the growing population chromosome. The term "fitness" is taken from the philosophy of evolution. It is exercised at this point because of suitability assessments and calculates how all probable resolution is "formed." One of the essential sections of the algorithm is the exercise variable, so at the end of this chapter, it is addressed in more depth. The word chromosome denotes an arithmetic assessment that reflects a contender result in difficulty being solved by the GA.
4. Selection: This selection procedure is done on the basis of the measured value in the context of the problem for any chromosome. Now, the selection of individual genomes from the chromosome sequence is made. Roulette wheel, grade collection, and steady-state choice are the widely employed methods of chromosome distribution.
5. Crossover: It is the cycle in which genes are chosen, and new embryos are produced from the parent chromosomes.
6. Mutation: In most optimization techniques, premature convergence is a critical problem, comprising of species, that happens when extremely suitable parent chromosomes in the population in early evolution produce several identical offspring. Genetic algorithms (GAs) crossover activity cannot produce particular offspring from their parents as the data obtained is used to cross the chromosomes. Unlike the convergence, an alternative agent, mutant, may search for new locations. Convergence is alluded to as an agent for manipulation, while the mutant is one of discovery. Mutant can be done for all forms of encoding methods as well as a crossover [3].
7. Go to step1 until finding the optimum solution.

V. IMPLEMENTATION OF GA TO PID CONTROLLER

A program is done in MATLAB for a fitness calculation of a classical controller to control BLDC Motor which is used in GA to change the PID controller string variables labeled as KP, KI, & KD. For the most part, the binary-coded sequence of digital values is cast-off. Usually, the length of twine is calculated by the required consistency of the solution. For code increasing element, 10 bits are used here, but a smaller number of bits like 8 bit & 4 bit can also be used. Then pick the population's random strings to shape the mating stream. We estimate the mean of fitness of all the individuals to use the roulette-wheel choice technique[5].

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Then in the crossover process, the breeding group is used. The succeeding move is to conduct an intermediate population sequence mutation.

Table 1: Parameters of GA

SL NO	Parameter	Value
1	Population size	20
2	Generations	100
3	Crossover fraction	0.5
4	Mutation fraction	0.05

The existing community is the new population. The entire progression is implied in MATLAB & we acquire the enhanced values of KP, KI & KD after running the program. Below is shown the simulation modal for the complete structure considering the genetic algorithm parameters for optimization.

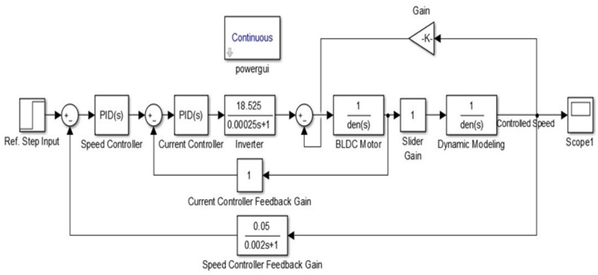

Figure-6: Simulation Modal of GA Based PID Controller

VI. RESULT AND ANALYSIS

The simulation diagram is shown in figure-6 and the considered GA parameters are given in table-1. Because of GA's display ability in the presence of large nonlinearities to achieve optimal tuning of electrical drive speed controllers. To configure PI and PID speed controller parameters in a brushless dc drive prone to nonlinearities, they are added here. Moreover, GA's can be used digitally to optimize performance for other operating conditions, e.g., maintaining space in the face of load shifts or other requirements, e.g., peak over-shooting or minimum response time as shown in the statistics below.

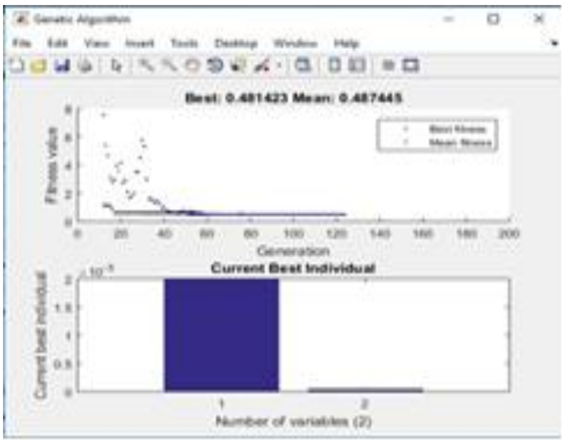

Figure-7: Variation of Fitness and current best individual best values for GA-PI combination

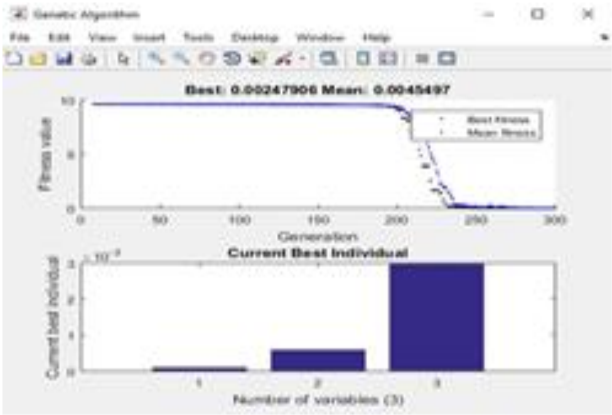

Figure-8: Variation of Fitness and current individual values for GA-PID combination

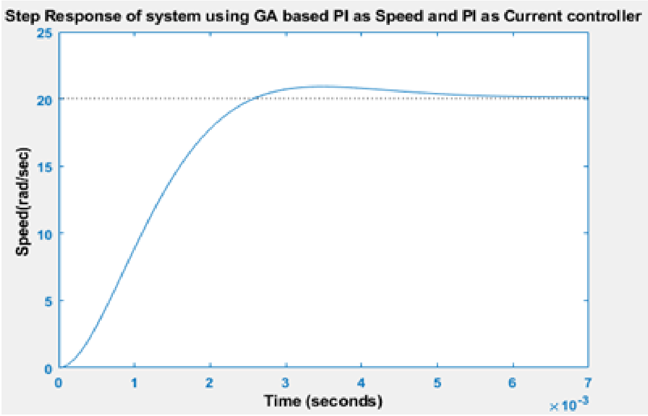

Figure-9: The step response of speed with GA-PI speed and PI current controller

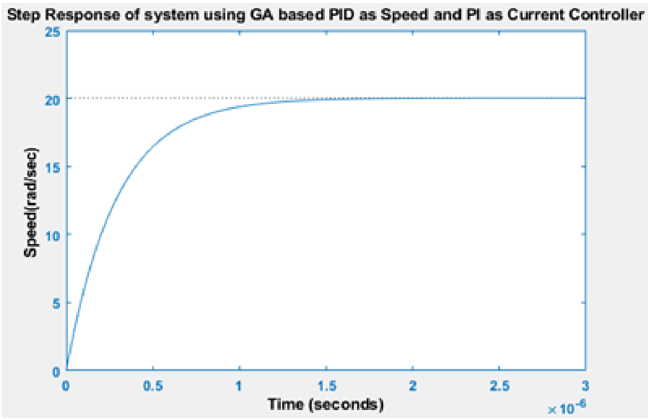

Figure-10: The step response of speed with GA- PID speed and PI current controller

The change in the fitness value and the best values of GA-PI and GA-PID combination is shown in figure-7 and 8 respectively. The figure-9 and 10 is showing the optimized response of the system by implying Genetic algorithm. The table-2 shows a comparative analysis of the same system's responses with a Genetic algorithm optimized PI and PID speed controller and proportional-integral current controller.

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From these data, it is found that the GA-optimized PID speed controller with PI as the current controller provides a stronger tailored response than the GA-optimized PI speed controller.

Table-2 Comparison of GA based Controller Performance

Sl no	Speed controller	Current controller	Rise time (Sec)	Peak time (Sec)	Peak overshoot %	Peak amplitud eRad/sec	Settling time (sec)	Final value Rad/sec
2	GA based PI	PI	0.00166	0.0035	4.37	20.9	0.00484	20
3	GA based PID	PI	6.4e^-07	3e^-06	2.22e^-06	20	1.14e^-06	20

VII. CONCLUSION

For any industrial application, the reliable output of a motor is needed. As the age of the motor improves its efficiency, so it is needed to assess the motor output from time to time for efficient operation. The modern method of calculating indexes of product efficiency is quite time-consuming. Genetic algorithms can be used in environments where there is inadequate machine awareness or great difficulty. For operators such as crossover and mutation, genetic algorithms may locate optimal solutions in the search space. Genetic algorithms are potent tools to find a reasonable solution to a complex issue fast. They're not fast, but they can do a decent quest. The genetic algorithm is being evaluated in this research to improve the efficiency of the BLDC drive based on traditional PID tuning. The answer to the BLDC drive was tested with the Genetic algorithm-based PI and PID speed regulator. Not only does the new GA-PID controller remove the over-shooting of the answer, but it also demonstrates the more significant improvement of the transient response of step input. Thus, it is inferred that GA-PID received a much better response to the speed control of BLDCM.

REFERENCES

1. R.Krishnan, “Electric Motor Drives Modeling, Analysis,and Control, Prentice-Hall Internationa Inc., New Jersey, 2001.
2. Upama Das, Pabitra Kumar Biswas and Sukanta Debnath, “Modeling and Simulation of Open Loop Model of Brush Less DC Motor by Using MATLAB Based Software” International Journal of Electronics, Electrical and Computational System IJEECS ISSN 2348-117X Volume 6, Issue 6 June 2017
3. T. O..Mahony, C J Downing and K Fatla, “Genetic Algorithm for PID Parameter Optimization: Minimizing Error Criteria”, Process Control and Instrumentation 2000 26-28 July 2000, University of Stracthclyde, pg 148- 153.
4. 10. H. L. Chan and K. T. Woo, “Closed Loop Speed Control of Miniature Brushless DC Motors” Journal of Automation and Control Engineering Vol. 3, No. 4, August 2015.
5. Petar Crnosija et al , “Optimization of PM Brushless DC Motor Drive Speed Controller Using Modification of ZieglerNichols Methods Based on Bodé Plots” EPE-PEMC 2006, Portorož, Slovenia1-4244-0121-6/06/$20.00 ©2006 IEEE.
6. P.Pillay ad R.Krishnan, “Modeling, Simulation and Analysis of a Permanent Magnet Brushless DC motor drive part II: The brushless DC motor drive,” IEEE Transactions on Industry application, Vol.25, May/Apr 1989
7. Upama Das, Pabitra Kumar Biswas and Sukanta Debnath, “A Comparative Study between Load and No-Load condition of Brushless DC Motor Drives by Using MATLAB”, Journal of Power Technologies, Volume 3, Page 281-286, 2018.
8. David E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning. The University of Alabama, Addison Wesley Publishing Company Inc, 1989.
9. Upama Das, Pabitra Kumar Biswas, “Performance Analysis for Open Loop Brushless DC Motor Drive”, International Journal of Engineering and Advanced Technology (IJEAT) Volume-8 Issue-6, August 2019,pp-1220-1228.
10. Bimbhra PS. Power electronics. New Delhi: Khanna; 2012.
11. Venkataratnam K. Special Electrical Machines. Universities Press (India) Private Limited.
12. Teck SL, Jabbar MA, Azixur MR. Permanent-magnet motors for brushless operation. IEEE Transactions on Industry Applications 1990; 26(1): pp. 124-129.
13. Teck SL, King JT, Tong HL, Kai SL. Servo performance of a BLDC drive with instantaneous torque control. IEEE Transactions on Industry Applications 1992; 28(2): pp. 455-462.
14. Adil U, Bhakti MJ, Bharat SR. A review of modeling, analysis and control methods of Brushless DC Motors. In: 2016 International Conference on Computation of Power, Energy Information and Commuincation (ICCPEIC), Chennai, 2016. pp. 337-343.
15. Ki YN, Woo TL, Choon ML, Jung PH. Reducing torque ripple of brushless DC motor by varying input voltage. IEEE Transactions on Magnetics 2006; 42(4) pp. 1307-1310.

AUTHORS PROFILE

Upama Das was born in Agartala city, Tripura, India, in 1985. She completed her diploma from Polytechnique Institute Narsingarh, Agartala, Tripura, India, B.Tech from WBUT, India and received her M. Tech Degree from the National Institute of Technology Agartala, Tripura, India, in Instrumentation specialization. She is presently pursuing a Ph.D. degree at the Department of Electrical and Electronics Engineering, National Institute of Technology, Mizoram, India. She is presently working as an Assistant Professor in Electrical and Electronics Engineering, National Institute of Technology Mizoram, Aizawl, India. Her research interests include Power electronics Converters and Machine Drives, instrumentation, and control.

E-mail: upama.eee@nitmz.ac.in

Pabitra Kumar Biswas was born in West Bengal, India, in 1980. He completed his B.Tech from Asansol Engg. College, WBUT, India. He received his ME. Degree from Bengal Engineering and Science University, West Bengal, India, and Ph.D. Degree in Electrical Engineering from National Institute of Technology, Durgapur, India. He is presently working as HOD and Assistant Professor in Electrical Engineering at the National Institute of Technology, Mizoram, India. He has published several research papers in National/ International Conference Records/ Journals. His research interests include Electromagnetic Levitation System, Active Magnetic Bearing and Power electronics Converters, and Machine Drives.

E-mail: pabitra.eee@nitmz.ac.in