

Design and Implementation of PID, GA and Fuzzy logic Controllers for an Electrical Drive with Various Noise Disturbances



G.Sundari, J.Shanmugapriyan

Abstract: It is a great challenge for human being to keep up the constant speed in drive when external Noise disturbances occur due to fluctuations of power supply. In order to avoid these issues, PID controllers are intended using predictable method such as Ziegler Nichols method. But finest level is not obtained in transient and steady state. During the MATLAB Simulation, the error is present transient and steady state behavior in conventional PID controllers. Hence it is necessary to design a PID controller with Novel intelligent technique for speed control of drive like fuzzy and Genetic Algorithm. It considers error as fitness function which is to be minimized using various GA operators such as mutation etc. The Drive will be operated with different external noises like sinusoidal noise, Saw tooth noise and Ramp noise and comparison between PID, GA and Fuzzy PID will be presented and their performances are studied.

Keywords: Noise disturbances PID controller, Genetic controller, fuzzy controller.

I. INTRODUCTION

In Lift,crane, Roboticmanipulators,rolling mills, locomotives,windmills and traction,electric drive are generally utilized. As the system has different acceleration and deceleration capabilities there is a requirement of desired speed , even under various load torque disturbances. Hence it is necessary to make the machine to run at a constant speed irrespective of load variations. It is also used to protect the drives from the external disturbances. Also the speed variations due to fluctuation to in the power supply can be eliminated through the speed control mechanism which improves the stability of the machine. Hence there are so many methods are available for control the drive .The FLC, and GA are some methods[1]. For these mehods it is required to produce the proper settling time,peakovershoot and steady state error. In this paper,the conventional PID control, genetic algorithm and FLC are utilised.At last their performances are analyzed.

II. MODELING OF DRIVE

The conventional PID controller, FLC, GA is some methods which requires to produce good transient response such as peak overshoot, good steady state response.

Revised Manuscript Received on August 12, 2020.

* Correspondence Author

Mrs. G,Sundarish, Assistant Professor, Department of Electrical and Electronics Engineering, RMK Engineering college, Chennai., India

Dr. J. Shanmugapriyanis, Associate Professor, Department of Electrical and Electronics Engineering, Vel Tech Multi Tech Dr Rangarajan Dr Sakunthala Engineering college, Anna university, Chennai, India

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an [open access](#) article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

This paper deals with those controllers performance. The various parameters are chosen drives are given below.

θ – Angular displacement

K_t – Torque constant

K_b – emf constant

T_1 –Torque for load

I_a – Current for armature

V_a –voltage for armature

R_a – Resistance of Armature

L_a – Inductance of Armature

Torque developed by any drive is directly proportional to flux and armature current

$$T = K_t I_a \quad (1)$$

Back emf is proportional to drive speed

$$E=K_b d\theta/dt \quad (2)$$

Torque equation is

$$d\theta/dt^2=1/J[K_t I_a-B(d\theta/dt)+T_1] \quad (3) \quad \text{The armature circuit has the following equation}$$

$$dI_a/dt=1/L[-RI_a+V_a-K_b(d\theta/dt)] \quad (4)$$

By using the above two basic equations, The mathematical model is designed.

III. CONVENTIONAL CONTROLLERS

PID controllers are the maximum working business controllers. The purpose of those controllers is found on three controlling developments: Proportional, Integral, and Differential. Proportional time period makes a swap to the yield that is corresponding to the fashionable error value. The integral action evacuate the compensate stated through the relative manage anyway reason a portion slack into the framework. The derivative controller yield is relative to the expenditure of trade of error which is utilized to diminish the essentialness of overshoot shaped by means of the fundamental thing. $U(t) = K_p + K_i e(t) dt + K_d (de(t))/dt$

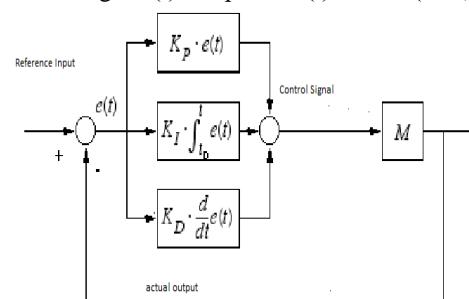


Fig.1. Schematic Diagram of PID Controller



IV. GENETIC ALGORITHM

The genetic algorithm is an approach for instructive both obliged and unconstrained keep learned issues that depends on upon common choice . Hereditary computation fit in with the further note worthy class of transformative computations, which manufacture answers for maturity issues by means of techniques pressed by normal headway, for illustration, bequest, change, quality of brain, and crossover. The GAs were by the side of necessary proposed by John Holland in 1970 . As a way to deal with locate infrequent reactions for issues that were all around computationally out of control. Holland's piece premise, this theory is in the vein of methodology called the principal hypothesis of transmissible calculations, is thoroughly taken to be the institution for elucidations of the power of procured figures. It says that short, low demand schemata with above-standard comfort growth exponentially in component times. In this paper,, GA is utilized to pick the ideal estimations of the PID controller parameters that fulfill the required segment execution attributes of the DC motor drive system. Fig. 3 demonstrates the activities of system GA based tuning of PID controller parameters. In the key, GA is introduced. By then, it makes starting persons of PID controller parameters. The general population is made frantically, covering the whole extent of possible arrangements. The general population is made out of chromosomes. Every chromosome is a nominee reaction for the issue. By then, the comfort respect for every genetic material is assessed utilizing as far as possible. In light of the wellbeing estimation of the initial, a get-together of best chromosomes is made the going with masses. After that, changes are connected with these surviving individuals to develop the going with occasion. The framework proceeds until the end normal is capable or the gauge of times is gone to its most noteworthy worth. Acquired inference is in like way examined to some ginning masses is the initial step of GAs. The masses are made out of the chromosomes that are parallel piece string. The relating examination of masses is known as the (wellbeing work) the wellbeing quality is degree3 the brook chart of GA is appeared in figure.2.

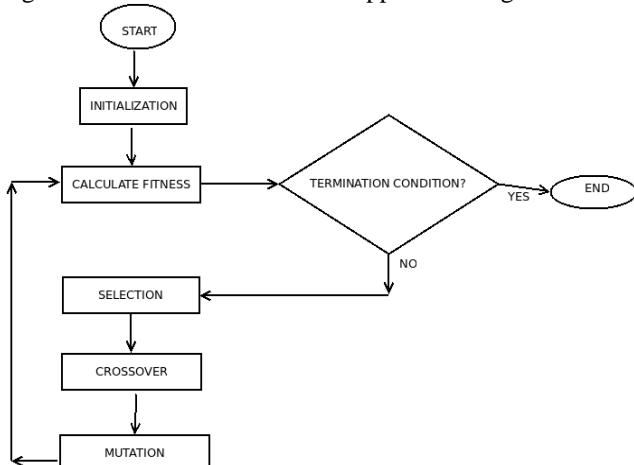


Fig 2.Chromosome structure

The parameter settings of GA is given below

Bit number	8
Crossover rate	0.6
Mutation rate	0.07
Population size	20
Generations	30

These parameters are constant across all runs. To illustrate the convergence of this algorithm the relationship between

the best fitness value and the average fitness value are graphical representation of the simulation results are shown in figure .4. From the graph, it was very clear that after 30 generations here there was no significant reduction in the objective function value and the corresponding parameter values are the optimum parameter values of the PID controller.

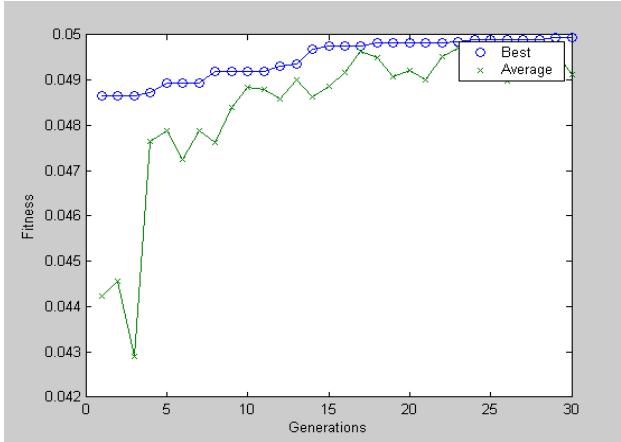


Figure.3.Convergence of GA-PID controller

V. FUZZY LOGIC CONTROLLER.

There is a vast development in the intelligent technique which is more encountered into the practice; for Example, artificial intelligent, robust control and adaptive control. They are used in which the mathematical model of the system is unknown or imprecise, or it is inapplicable and complex for the purpose of control.Fuzzy logic controller may be designed by applying human knowledge after exploitation of the fuzzy logic. The main use for fuzzy controller is adjusting certain parameters to be used for controlling a known system (known parameters). The parameter adjustment is done by testing them on the system where it is very difficult to adjust them by their influence because fuzzy controller is nonlinear.

Forty nine Rules fuzzy design

For the design of fuzzy controller,it is recommended to have more membership functions to describe the inputs and output. In the same time; it required forty nine rules to cover all the possible inputs as shown in the Table.1

	NB	NM	NS	ZR	PS	PM	PB
NB	NB	NB	NB	NB	NS	ZR	PS
NM	NB	NB	NB	NM	NS	ZR	PS
NS	NB	NB	NM	NS	ZR	PS	PM
ZR	NB	NM	NS	ZR	PS	PM	PB
PS	NM	NS	ZR	PS	PM	PB	PB
PM	NS	ZR	PS	PM	PB	PB	PB
PB	ZR	PS	PM	PB	PB	PB	PB

Table-1: Fuzzy Nine Rules fuzzy controller design

VI. SIMULATION RESULTS

The PID controller of the Drive is tuned by means of Ziegler-Nichols method. The tuning results are given below.

The tuning values from this algorithm are

$$K_p = 0.8531; K_d = 0.0047; K_i = 38.7769$$

After the PID controller parameters were tuned , the speed regulation of the DC motor is obtained under the following nonlinearities as shown in fig.4.a ,fig.4.b,fig.4.c



- a) At Sinusoidal Noise
- b) At saw tooth noise
- c) At Ramp Noise

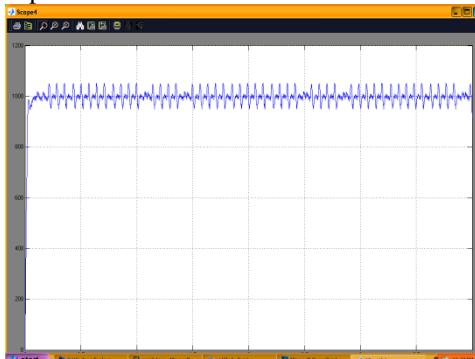


Fig.4.a. Conventional PID controller response for Sinusoidal

Noise Disturbances (Speed of DC drive(rpm) Vs time(ms) Disturbances)

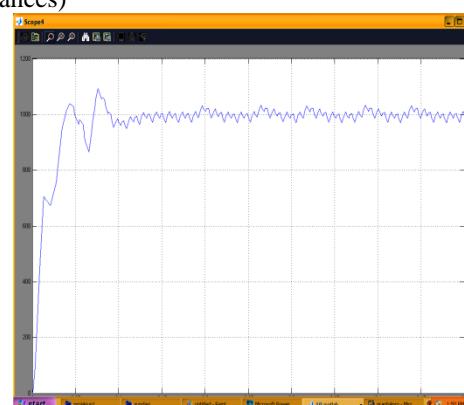


Fig.4.b. Conventional PID controller response for Saw tooth Noise Disturbances(Speed of DC drive(rpm) Vs time(ms) Disturbances)

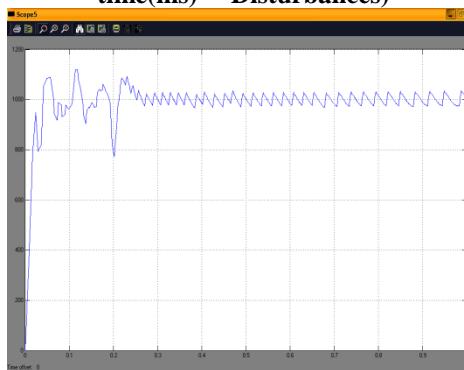


Fig.4.c. Conventional PID controller response for Ramp Noise Disturbances (Speed of DC drive(rpm) Vs time(ms))

The Convergence of GA-PID controller are $K_p = 0.7531$; $K_d = 0.0037$; $K_i = 37.6769$. The optimum K_p, K_d, K_i values are given to the PID controller of the simulation circuit and the speed regulation of the DC motor is obtained under the following circumstances given in fig.5.a, fig.5.b and fig.5.c.

- a) At Sinusoidal Noise Disturbances
- b) At Saw tooth noise Disturbances
- c) At Ramp Noise Disturbances

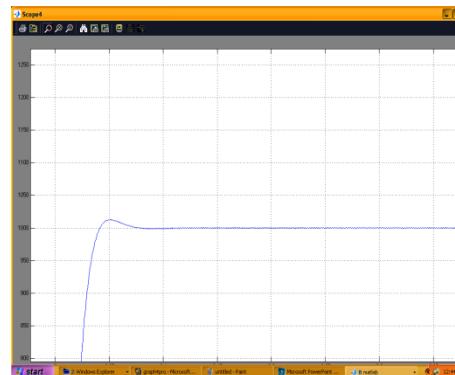


Fig.5.a. GA-PID controller response for Sinusoidal Noise Disturbances



Fig.5.b. GA-PID controller response for Sawtooth Noise Disturbances (Speed of DC Drive(rpm) Vs time(ms))

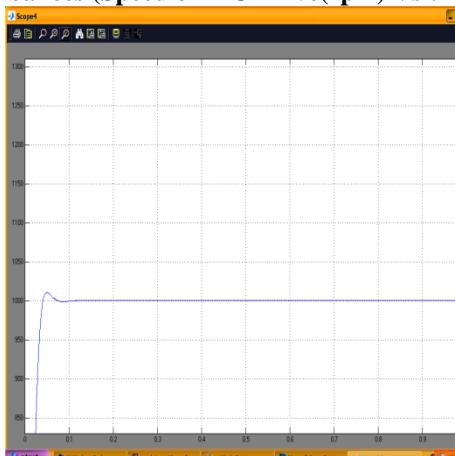


Fig.5.c. GA-PID controller response for Ramp Noise Disturbances (Speed of DC Drive(rpm) Vs time(ms))

After the PID controller parameters were tuned by using fuzzycontroller with different noise disturbances as shown in fig.6.a, fig.6.b, fig.6.c

- a) At Sinusoidal Noise
- b) At saw tooth noise
- c) At Ramp Noise

Design and Implementation of PID, GA and Fuzzy logic Controllers for an Electrical Drive with Various Noise Disturbances

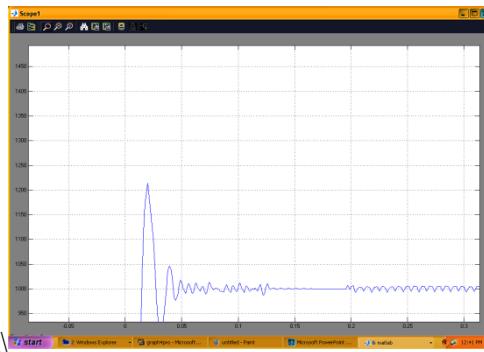


Fig.6.a.Fuzzy controller response for Sinusoidal Noise Disturbances (Speed of DC Drive(rpm) Vs time(ms)

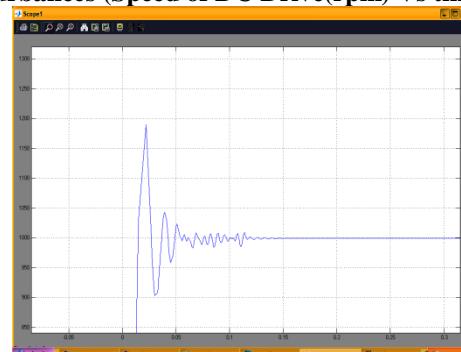


Fig.6.b.Fuzzy controller response for Sawtooth Noise Disturbances (Speed of DC Drive(rpm) Vs time(ms)

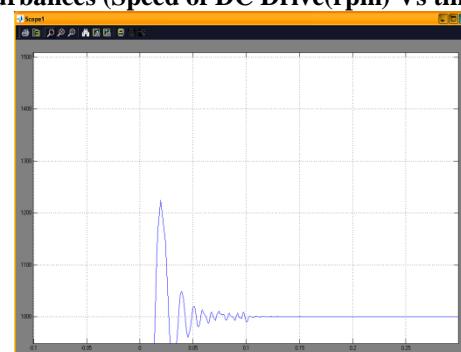


Fig.6.C.Fuzzy controller response for Ramp Noise Disturbances (Speed of DC drive(rpm) Vs time(ms))

The performances of fuzzy, GA-PID controllers are carried for DC drive and it is compared with conventional controller in MATLAB computer simulation. It is demonstrated that the suitability of the proposed method and the speed control of the drive was obtained using under the following Noise Disturbances. The comparison table is listed as shown Table.3, Table.4 and Table.5 for conventional controller, GAPID controller, FLC at different Noise Disturbances.

Table-3: Comparison table for Sinusoidal Noise Disturbances

Controller	Steady state error(rpm)	Steady state value (rpm)	Settling time (msec)	Peak overshoot (msec)
Conventional controller	100	1050	Infinite	50
GAPID controller	0.2	1000	0.08	12.5
Fuzzy Controller	10	999	0.2	200

Controller	Steady state error(rpm)	Steady state value (rpm)	Settling time (msec)	Peak overshoot (msec)
Conventional controller	50	995	Infinite	98
GAPID controller	0.1	1000	0.03	13
Fuzzy controller	0.25	998	0.15	180

Table -4: Comparison Table for Sawtooth Disturbances

Controller	Steady state error(rpm)	Steady state value(rpm)	Settling time(msec)	Peak overshoot (msec)
Conventional controller	45	998	0.3	125
GAPID controller	0.2	1000	0.125	15
Fuzzy controller	0.5	1000	0.12	225

Table -5: Comparison table Ramp Disturbances

VII. CONCLUSION

A new approach based on fuzzy set theory and Genetic Algorithm have been proposed and demonstrated for designing hybrid controller for controlling the speed of the higher order drives which is capable of providing good speed regulation with stability. In this paper, Ziegler Nichols was used to tune the PID controller which was suitable only for the linear process. The experimental results show that the GA- PID controller produces better speed control under the linear load disturbances in such a way that it reduces the settling time and overshoot. At last FLC was used for better speed control which produces the satisfactory speed control of the drive under nonlinear loaded conditions by reducing overshoot, settling time. And Results from this paper, one can reveal that under various load disturbances, intelligent controller provides the better performance than the conventional controllers and Genetic PID controllers

REFERENCES

- Younis S. Dawood , Ali K. Mahmood and Muhammed "Comparison of PID, GA and Fuzzy Logic Controllers for Cruise Control System ", A. International Journal of Computing and Digital Systems ISSN (2210-142X) Int. J. Com. Dig. Sys. 7, No.5 (Sep-2018)
- Ramesh Chandra Chourasia, Mukesh Kumar , "Speed Control of S.E.D.C. Motor by Using Pi and Fuzzy Logic Controller", International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-3, Issue-2, May 2013
- Umesh Kumar Bansal and Rakesh Narve, "Speed Control of DC Motor Using Fuzzy PID Controller". ISSN 2231-1297,Volume 3, Number 9 (2013), pp. 1209-1220 © Research India Publications

4. Sharad Chandra Rajpoot¹, Prashant Singh, Rajpoot², Premlata³, Durga Sharma⁴“Design and Simulation of Neuro Fuzzy Controller for Speed Control of a Separately Excited dc Motor”, IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 11, Issue 6 Ver. IV (Nov. – Dec. 2016), PP 56-67
5. Hybrid control technique for minimizing the torque ripple of brushless direct current motor”Measurement and Control 2018, Vol. 51(7-8) 321-335 © The Author(s) 2018 Article reuse guidelines: sagepub.com/journals-permission
6. Akbarzadeh M.R , Kim T, Y.T. &B.Feerouzbakhah, ‘Evolutionary Fuzzy speed regulation for a DC motor’],” NASA Center for Autonomous control Engineering,
7. Chin- Hung wang, Tzung- Pei Hong, and Shian- Shyong Teng” Integrating Fuzzy knowledge by Genetic Algorithms”, (1998), ,IEEE Transactions on Evolutionary computation, VOL.2, No.4.
8. Abdulla Ismail and Sharaf A.M (2002),”An Efficient Neuro Fuzzy speed controller for Large Industrial Motor Drives,” IEEE International conference on Control Applications, September 18-20,2002,Glasgow, Scotland,U.K.
9. Chin- Hung wang, Tzung- Pei Hong, and Shian- Shyong Teng (1998)]‘Evolutionary Fuzzy speed regulation for a DC motor’, NASA Center for Autonomous control Engineering,

AUTHORS PROFILE



Mrs. G, Sundari has been perusing Research leading to PhD in Anna university, Chennai, India and she has completed master degree in Electrical and Electronics Engineering at Arulmigu Kalasalingam college of Engineering, Srivilliputthur, Anna university She had been working as an Assistant professor in EEE at RMK Engineering college, Chennai.



National journals.

Dr. J. Shanmugapriyan is an Associate Professor in the department of Electrical and Electronics Engineering at VelTech MultiTech Dr. Rangarajan Dr. Sakunthala Engineering college, Anna university, Chennai. His area of interests are power Electronics and Drives and VLSI Design. He has published 18 papers inclusive of International and