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Enhancement of stability and accuracy of the SEDC Motor under the effect of the external disturbances and noise by using Fuzzy-Genetic controller

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Abstract: For electrical drives good dynamic performance is mandatory so as to respond to the changes in command speed and torques, so various speed control techniques are being used for real time applications. The speed of a DC motor can be controlled using various controllers like PID Controller, Fuzzy Logic Controller, Genetic Algorithm (GA) controller and Hybrid Fuzzy-Genetic Controller. Fuzzy-Genetic Controller is recently getting increasing emphasis in process control applications. The paper describes application of Hybrid Fuzzy-Genetic Controller in an enhancement of stability and accuracy of the SEDC Motor under the effect of the external disturbances and noise that uses the Fuzzy-GA Controller for enhancement of stability and accuracy of the SEDC Motor under the effect of the external disturbances and noise is implemented in MATLAB/SIMULINK. The simulation study indicates the superiority Hybrid Fuzzy-Genetic Controller over the Genetic Algorithm and fuzzy logic controller separately. This control seems to have a lot of promise in the applications of power electronics. The speed of the SEDC motor can be adjusted to a great extent so as to provide easy control and high performance. There are several conventional and numeric types of controllers intended for controlling the SEDC motor speed and executing various tasks: PID Controller, Fuzzy Logic Controller; or the combination between them: Fuzzy-Swarm, Fuzzy-Neural Networks, Fuzzy-Genetic Algorithm, Fuzzy-Ants Colony. We describe in this paper the use of Hybrid Fuzzy-Genetic Controller for enhancement of stability and accuracy of the SEDC Motor under the effect of the external disturbances and noise. In this case, the obtained results were simulated on Simulink of Matlab.

Keywords: Separately Excited DC Motor (SEDC), Fuzzy Logic Controller (FLC), Genetic Algorithm (GA).

I.INTRODUCTION

In spite of the development of power electronics resources, the direct current machine became more and more useful. Nowadays their uses isn't limited in the car applications (electrics vehicle), in applications of weak power using battery system (motor of toy) or for the electric traction in the multi-machine systems too. The speed of DC motor can be adjusted to a great extent as to provide controllability easy and high performance [1, 2]. The controllers of the speed that are conceived for goal to control the speed of DC motor to execute one variety of tasks, is of several conventional and numeric controller types, the controllers can be: PID Controller, Fuzzy Logic Controller; or the combination between them Fuzzy-Genetic Algorithm, Fuzzy-Neural Networks, Fuzzy-Ants Colony, Fuzzy-Swarm (Swarm). Fuzzy theory was first proposed and investigated by Prof. Zadeh in 1965.

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The Mamdani fuzzy inference system was presented to control a steam engine and boiler combination by linguistic rules [3, 7]. Fuzzy logic is expressed by means of if-then rules with the human language. In the design of a fuzzy logic controller, the mathematical model is not necessary. Thus, the fuzzy logic controller owns good robustness. Fuzzy controller has been widely used in industry for its easy realization. However, the rules and the membership functions of a fuzzy logic controller are constructed by expert experience or knowledge database. Much work has been done on the analysis of fuzzy control rules and membership function parameters [3]. In 1960, Prof. Holland introduced genetic algorithms [4, 5]. Genetic algorithms are applied to search the globally optimal solution of problems. The evolution process of genetic algorithms is based on the natural selection. Genetic algorithms employ chromosomes through three operations, reproduction, crossover, and mutations to generate offspring for next iterations.

The advantages of genetic algorithms are derivative-free stochastic optimization, parallel-search procedure and applicable to both continuous and discrete problems. Recently, there have been some researches in discussing the design of fuzzy controller with genetic algorithms. In [5, 6, 7], genetic algorithms are applied to adjust the ranges of membership functions. However, the expert experiences or knowledge are still required for the shapes of membership functions and fuzzy inference rules. In [8, 9, 10], genetic algorithms are applied to choose membership functions and fuzzy rules. However, the expert experiences or knowledge are still necessary for the ranges of membership functions. In this paper, a novel strategy is proposed to design the optimal fuzzy controller. Genetic algorithms are applied to search the globally optimal parameters of fuzzy logic. The best ranges of membership functions; the best shapes of membership functions and the best fuzzy inference rules are dug out at the same time. Furthermore, the performances of three different fuzzy logic controllers are compared. Computer simulations demonstrate the optimal design is effectiveness.

II. MODELING WITHOUT & UNDER THE EFFECT OF THE LOAD

The S.E.DC motor transfer function without load is shown in the block diagram in Fig.1. The equations of The SEDC motor in terms of armature control based on Newton's law combined with Kerchief's law are as follows:

$$V_a = L_a \cdot \frac{di_a(t)}{dt} + R_a i_a(t) + e_b \qquad (1)$$

$$L_a \cdot \frac{di_a(t)}{dt} + R_a i_a(t) = V_a - K_b \frac{d\theta}{dt} \qquad (2)$$

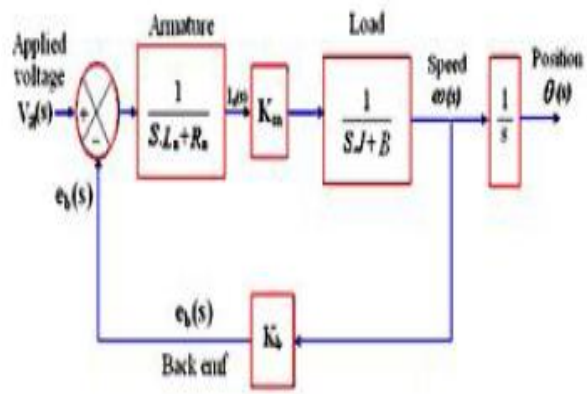

Fig.1 Block diagram of S.E.DC motor without load (Td)

The motor torque equation is

$$T_m = J.\frac{d^2\theta}{dt^2} + B.\frac{d\theta}{dt} = K_m i_a(t) \qquad (3)$$

Where

$T_m = T_L + T_d$

At (Td=0) which without disturbance torque (External Disturbance and Noise), $T_m = T_L$. Where TL is the load torque, Td is the disturbance torque &Tm is The motor torque. Using the Laplace transform for equations (1), (2) and (3) assuming initial conditions equal zero can be written as

$$(L_a s + R_a) I_a(s) = V_a(s) - K_b s\theta(s) \qquad (4)$$

$$s(Js + B)\theta(s) = K_m . I_a(s) \qquad (5)$$

$$T_m(s) = T_d(s) + T_L(s)$$

$$s(Js + B)\theta(s) = K_m . \frac{V_a(s) - K_b s\theta(s)}{R_a + L_a s} \qquad (6)$$

Where s denotes the Laplace operator. From equation (4) $I_a(s)$ is given as follow:

$$I_a(s) = \frac{V_a(s) - K_b s\theta(s)}{R_a + L_a s} \qquad (7)$$

by substituting it in equation (5) to obtain

$$\frac{\omega(s)}{V_a(s)}=\frac{K_m}{(Js+B)(L_a s+R_a)+K_m K_b} \quad (8)$$

The S.E.DC motor transfer function of armature control from the applied armature voltage (input voltage), $V_a(s)$, to speed (the angular velocity) $s\theta(s)=\omega(s)$ without load Which is $(T_d(s)=0)$. The S.E.DC motor transfer function without load is shown in the block diagram in fig. 1. The transfer function given by equation (8) may be written in terms of the time constants of the motor as follows

$$\frac{\omega(s)}{V_a(s)}=\frac{K_m}{R_a B\ (1+s\tau_a)(1+s\tau_m)+K_m K_b} \quad (9)$$

Where

τ_a L_a/R_a = time constant of armature circuit.

τ_m J/B = mechanical time constant.

S.E.DC motor transfer function of armature control from the Applied armature voltage (input voltage) Va(s) to speed (the angular velocity) $\omega(s)$ with load $T_d(s)$ will become as follows:

$$\omega(s)=\frac{K_m}{(Js+B)(L_a s+R_a)+K_m K_b}V_a(s)-\frac{L_a s+R_a}{(Js+B)(L_a s+R_a)+K_m K_b}T_d(s) \quad (10)$$

S.E.DC motor transfer function with load Td(s) is shown in the block diagram in Fig.2 [11-12].

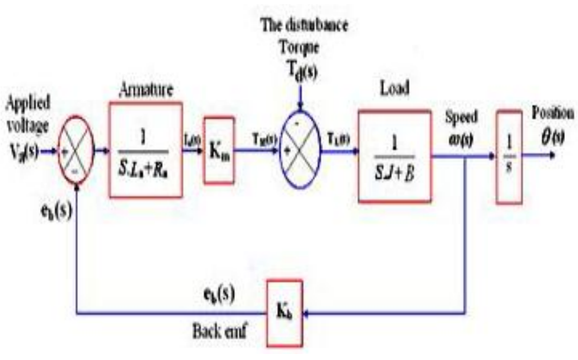

Fig. 2 Block diagram of S.E.DC motor with load (Td)

III. FUZZY LOGIC CONTROLLER

The concept of fuzzy logic was developed by Lotfi Zadeh in 1964 to address uncertainty and imprecision which widely exist in engineering problems. Fuzzy modeling is the method of describing the characteristics of a system using fuzzy inference rules. The method has a distinguishing feature in that it can express linguistically complex nonlinear systems. It is however, very hard to identify the rules and tune the membership functions of the fuzzy reasoning. Fuzzy controllers are normally built with the use of fuzzy rules. These fuzzy rules are obtained either from domain experts or by observing the people who are currently doing the control. The membership functions for the fuzzy sets will be derived from the information available from the domain experts and/or observed control actions.

The building of such rules and membership functions require tuning. That **is,** performance of the controller must be measured and the membership functions and rules adjusted based upon the performance. This process will be time consuming. The basic configuration of Fuzzy Logic Controller (FLC) consists of four main parts (i) Fuzzification where values of input variables are measured and a scale mapping that transforms the range of values of input variables into corresponding universe of discourse is performed then performs the function of fuzzification that converts input into suitable linguistic values, which may be, viewed labels of fuzzy sets. (ii) Knowledge Base consists of data base and linguistic control rule base. The database provides necessary definitions, which are used to define linguistic control rules and fuzzy data, manipulation in an FLC. The rule base characterizes the control goals and control policy of the domain experts by means of set of linguistic control rules. (iii) The Decision Making Logic, it has the capability of simulating human decision making based on fuzzy concepts and of inferring fuzzy control actions employing fuzzy implication and the rules of inference in fuzzy logic. (iv) The Defuzzification a scale mapping which converts the range of values of input variables into corresponding universe of discourse [13-17].

In view to make the controller insensitive to system parameters change, fuzzy logic theory is also implemented by researchers extensively. Indulkar et. al [18] initially designed a controller using fuzzy logic for automatic generation control and responses were compared with classical integral controller. Chang et. al. [19] presented a new approach to study the LFC problem using fuzzy gain scheduling of proportional-integral controllers and proposed scheme has been designed for a four area interconnected power system with control deadbands and generation rate constraints. Ha [20] applied the robust sliding mode technique to LFC problem where, control signal consists of an equivalent control, a switching control and fuzzy control with generation rate constraints and governor's backlash on the other hand the fuzzy controller designed by Chown et. al [21] when implemented not only grid was controlled better but also more economically.

Talaq et. al [22] in their research proposed an adaptive controller which requires less training patterns as compared with a neural net based adaptive scheme and performance was observed better than fixed gain controller. Ha et. al [23] proposed an approach which combines the salient features of both variable structure and fuzzy systems to achieve high performance and robustness.

Fuzzy logic controller, designed by El-Sherbiny [24], is a two layered fuzzy controller with less overshoot and small settling time as compared with conventional one. Ghoshal [25] presented a self adjusting, fast acting fuzzy gain scheduling scheme for conventional integral gain automatic generation controller for a radial and ring connected three equal power system areas. Yensil et. Al [26] proposed a self tuning fuzzy PID type controller for LFC problem and satisfactory results are found when compared with fuzzy PID type controller without self tuning.

IV. GENETIC ALGORITHM

One of the newer and relatively simple optimization approaches is the genetic algorithm (GA). Perhaps one of the most attractive qualities of GA is that it is a derivative free optimization tool. Hence, it does not rely on a detailed model of the system to be optimized. This superiority of GA, over other algorithms or search techniques, becomes apparent when the search space is large or discontinuous; however, it can be equally useful in problems similar to the one at hand, where optimization is performed more than just a few times. The GA starts by randomly creating an initial population of binary strings. Each of these strings is called a chromosome, and it represents a candidate solution to the search problem.

The binary strings are then converted to their decimal equivalents and tested to how "fit" they are. A better solution should be reflected in a higher fitness function. The fitness function is an integral part of the algorithm and it is practically the only channel between the algorithm and the problem being solved. Therefore, it should be carefully chosen. GA employs three operators: reproduction, crossover, and mutation. To create new generation, fitness-proportionate reproduction is achieved through a weighted roulette wheel. Consequently, fitter chromosomes have higher probability of reproduction. Next, crossover is performed on two strings (at a time) that are randomly selected from the population. Crossover involves choosing a random position in the two strings and swapping the binary bits that occur after this position. It is performed on only a specified percentage of each generation.

The final operation, mutation, is performed providently, typically every 100 or more crossover operations. It involves choosing a random string and a random bit within the string. The bit is changed from 1 to 0, or visa-versa. By the end of mutation operator, a new generation is complete and the process is repeated by evaluating the new fitness. GA is a global search technique based on mechanics of natural selection and genetics. It is a general-purpose optimization algorithm that is distinguished from conventional optimization by the use of concepts of population genetics to guide the optimization search. In recent years GA is gaining popularity for its easy searching process, global optimality, Independence of searching space and probabilistic nature. Instead of point-to-point search, GA searches from population to population.

Although it has many advantages but the main disadvantage is that it requires tremendously high time [27-31]. Alander [32] has presented an extended bibliography of GA in power system. Magid et al. [33, 34] used GA for optimizing the parameters of conventional automatic generation control systems and demonstrated the effectiveness of the GA in tuning of the AGC parameters. Dangprasert et. at [35] proposed GA based intelligent controller for load frequency control problem and results obtained provided good system characteristics.

A real coded GA is adopted and integrated into MATLAB/Simulink in [36] and simulation results are found reasonable while [37] reported optimum gain setting of different type of controllers for a two area hydro system and analysis revealed that PID controllers give better dynamic responses for a two area hydro system. Abdennour [38] suggested GA to optimize the integral gain for a number of operating conditions of power system and his comparison reveals that the proposed scheme can be an attractive alternative from both performance and design point of view. [39] presented two different methodologies for LFC problem one is based on H∞ control design using linear matrix inequalities technique and second is GA optimization to achieve the same performance as that of first one. Both controllers were tested to demonstrate their robust performances. Chia-Feng Juang et. at in [40] gave a GA based fuzzy gain scheduling approach for power system load frequency control. The flow chart of genetic algorithm is described below.

[Start] Generate random population of n chromosomes (suitable solutions for the problem).

[Fitness] Evaluate the fitness f(x) of each chromosome x in the population.

[New population] Create a new population by repeating following steps until the new population is complete.

a) Selection. Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected).

b) Crossover. With a crossover probability, cross over the parents to form new offspring (children). If no crossover was performed, offspring is the exact copy of parents.

c) Mutation. With a mutation probability, mutate new offspring at each locus (position in chromosome).

d) Accepting. Place new offspring in the new population.

[Replace] Use new generated population for a further run of the algorithm.

[Test] If the end condition is satisfied, **stop**, and return the best solution in current population.

[Loop] Go to step 2.

The objective functions are MSE (Mean Square Error), IAE (Integral Absolute Error), ISE (Integral Square Error) and ITAE (Integral Time Absolute Error). The main objective of PID controller is to minimize the error signal or in other words we can say that minimization of performance indices.

$$MSE = \frac{1}{t}\int_0^t (e(t))^2 \qquad (14)$$

$$IAE = \int_0^t |e(t)|\,dt \qquad (15)$$

$$ISE = \int_0^t |e(t)|^2\,dt \qquad (16)$$

$$ITAE = \int_0^t t\,|e(t)|\,dt \qquad (17)$$

Figure 3 shows the Flow chart of genetic algorithm, The fitness value of the chromosome is the inverse of the performance indices. The fitness value is used to select the best solution in the population to the parent and to the offspring that will comprise the next generations. The fitter the parent greater is the probability of selection. This emulates the evolutionary process of "survival of the fittest". Parents are selected using roulette wheel selection method. Fitness function is reciprocal of performance indices. In this paper we have taken the discrete form of ITAE. ITAE is treated as performance indices and fitness function denoted by J can be described below in Equation

$$J = \frac{1}{\sum_{k=0}^{N-1}[\{r(kT) - c(kT)\}T]} \qquad (18)$$

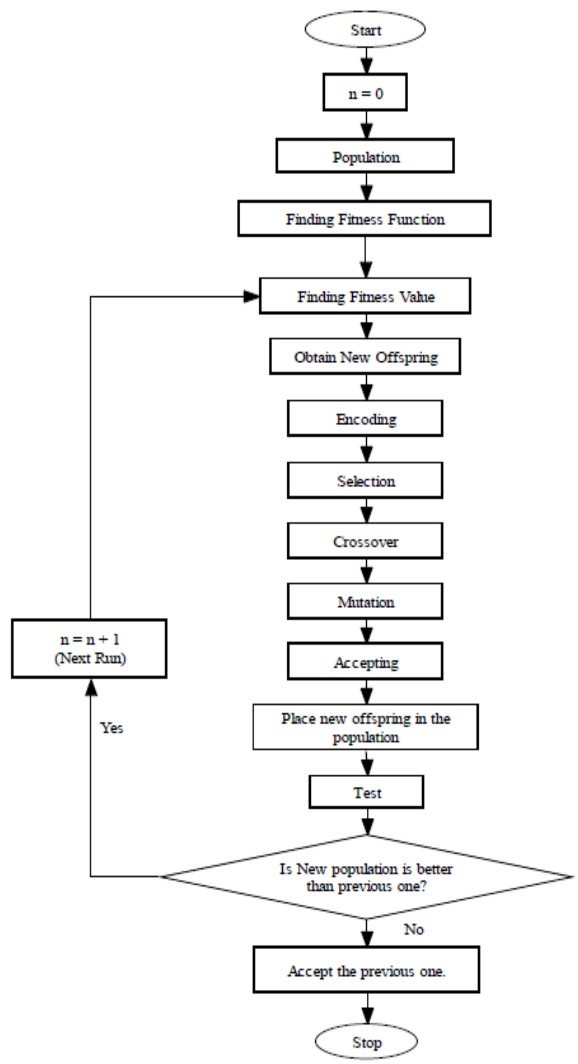

Figure 3. Flow chart of Genetic Algorithm

V. The Proposed Hybrid Fuzzy pulse Genetic Controller

GA is a stochastic optimization algorithm is originally motivated by the mechanisms of nabural selection and evolutionary genetics. The GA serves, as a computing mechanism to solve the constrained optimization problem resulting. from the motor control design where the genetic structure encodes some sort of automation. The basic element processed by a GA is a string formed by concatenating substrings, each of which is a binary coding (if binary **GA** was adopted) of a parameter. Each string represents a point in the search space.

The Selection, Crossover and Mutation are the main operations of GA. Selection directs the search of Gas toward the best individual. In the process, strings with high fitness receive multiple copies in the next generation while strings with low fitness receive fewer copies or even none at all. Crossover can cause to exchange the property of any two chromosomes via random decision in the mating pool and provide a mechanism to product and match the desirable qualities through the crossover. Although selection and crossover provide the most of the power skills, but the area of the solution will be limited. Mutation is a random alternation of a bit in the string assists in keeping delivery in the population.

The optimization step of GA is follow:

1. Code the parameter
2. The initialization of the population
3. Evaluate the fitness of each member
4. Selection
5. Crossover
6. Mutation

The genetic algorithm technique employed in this study is used to tune the fuzzy logic controller based on the method described in [41]. The tuning approach employs the use of MATLAB M-files and functions to manipulate the fuzzy inference system and scaling gains, run simulation, check the resulting performance and continuously modify the fuzzy inference system for a number of times in search for an optimal solution. The integral of absolute error is used as a measure of the system performance since it is known to give a better all round performance indicator of a control system response where overshoot, settling time and rise time are the main considerations [42].

$$(IAE = \int_0^\infty |e(t)dt|) \qquad (19)$$

VI.DESIGN REQUIREMENTS FOR THE SYSTEM

The most basic requirement of S.E.DC motor is that it should be rotated at the desired speed without and under the effect of loads (external disturbances and noise) and intelligent controller is used for reducing the sensitivity of actual response as to load variations (external disturbances and noise), where the actual response variations that have been induced by such external disturbances and noise must be minimized rapidly. The steady-state error of the S.E.DC motor speed should be minimized. The other performance requirement is that motor must accelerate to its steady-state speed as soon as it turns on, The SEDC motor is driven by applied voltage. The reference input (applied voltage) (V) is simulated by unit step input, then an actual response of S.E.DC motor should have the design requirements for the system as follows

(i) Minimize the maximum overshoot

(ii) Minimize the rise time

(iii) Minimize speed tracking error

(iv) Minimize the steady state error

(v) Minimize the settling time

(vi) The system is controllable and observable

(vii)All roots of characteristic equation are lying in the left half of s-plane.

(viii) Damping ratio (ζ) is between (0.4 & 0.86).

The speed of a SEDC motor could be varied from zero to rated speed mainly by varying armature voltage in the constant torque region. Whereas in the constant power region, field flux should be reduced to achieve speed above the rated speed. The motor drives a mechanical load characterized by inertia J, Viscous friction coefficient B, and load torque T_L. The specifications of the SEDC motor are given in table 1.

Armature resistance R_a	2.0 Ohm
Armature inductance L_a	0.5 H
Field resistance R_f	240 Ohm
Field inductance L_f	120 H
Shaft power P	5 hp
The motor torque constant Km	0.1
The back e.m.f constant Kb	0.1
The tachometer constant Kt	1
Viscous friction coefficient B	0.2 Nms
Total inertia J	0.02 kgm^2
Rated voltage V	240 V

Table 1. The specifications of the SEDC motor

VII.SIMULATION RESULTS

Fig. 4 shows The structure of the fuzzy controller with GA and Fig. 5-7 shows results of simulation (Matlab environment) of a Enhancement of stability and accuracy of the SEDC Motor without and under the effect of the external disturbances and noise by intelligent controller (Fuzzy logic controller, Genetic Algorithm (GA), FLC+GA). The actual response of FLC+GA Controller comparing with the actual response of FLC, and GA is shown in Fig. 7. Table2 lists the Comparison of the performances of Fuzzy, GA and hybrid Fuzzy-GA controllers, to show the effectiveness of the proposed approach.

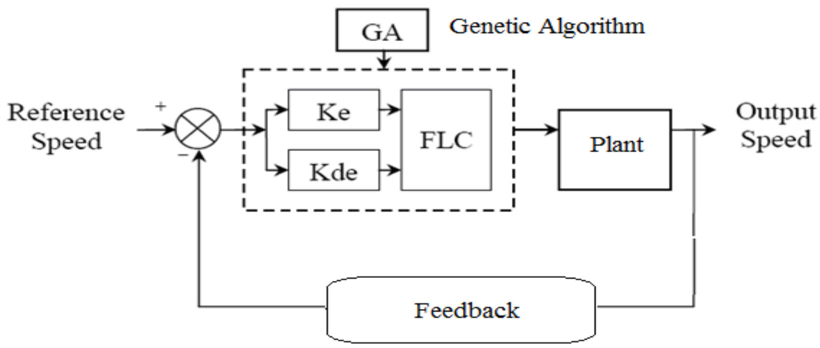

Figure. 4 FLC with GAs structure.

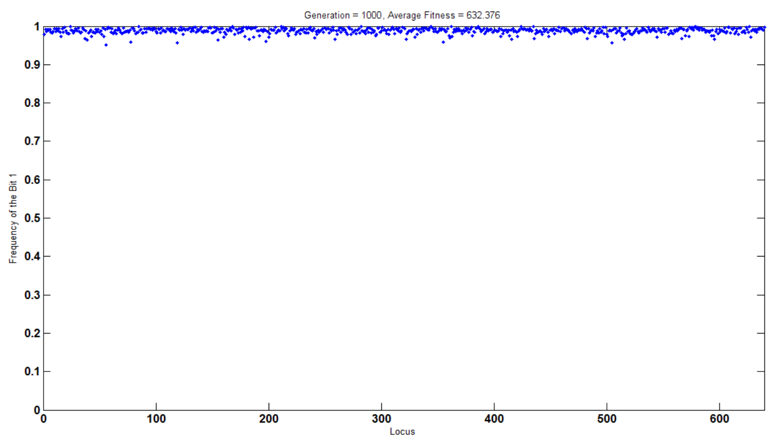

Figure 5 Genetic Algorithm of the system

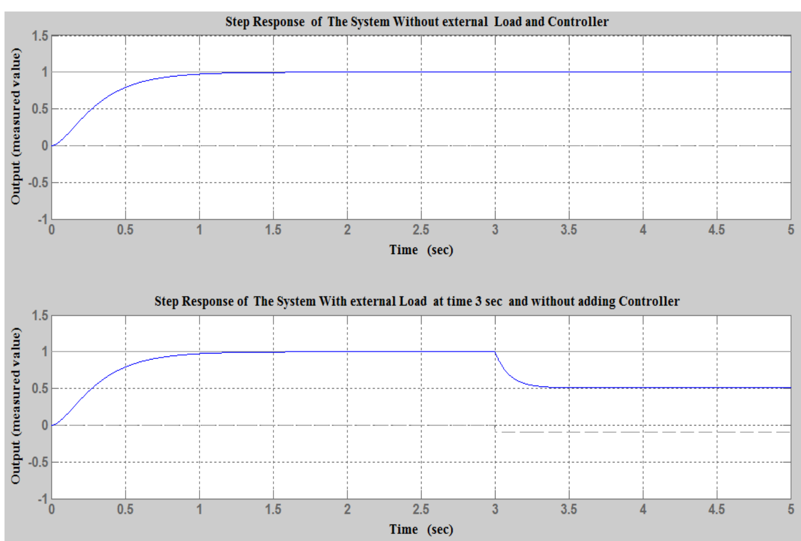

Figure 6 Step response of the system with external load at time 3 sec and without adding controller

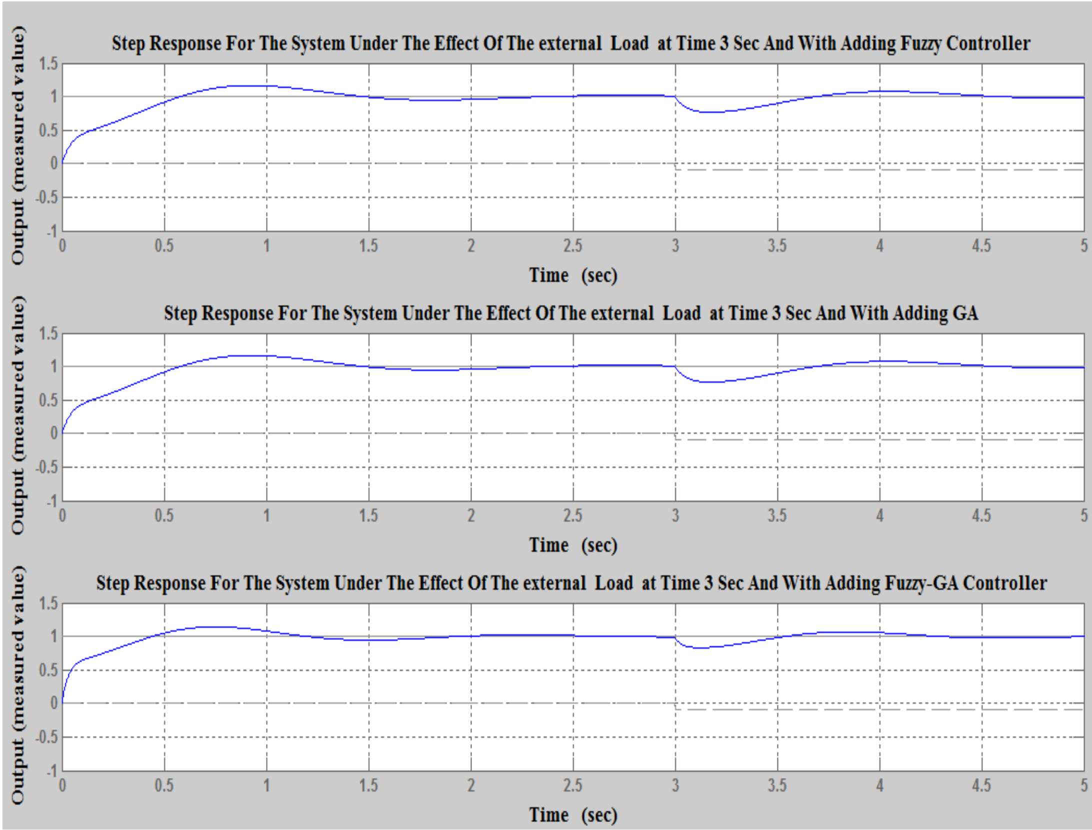

Figure 7 simulation results of the comparison among the Fuzzy, GA and hybrid Fuzzy-GA controller.

SEDC motor under the effect of the load variation, External disturbances and noise at time t = 3 (sec)			
specifications	**Strategy of control**		
	Fuzzy Logic control method	**GA control method**	**Fuzzy-Genetic control method**
Damping ratio (ξ)	**0.7946**	**0.7946**	**0.7946**
Settling Time (t_s)	**0.383 sec**	**0.3830**	**0.3830**
Maximum Overshoot (%M_p)	**1.6373 %**	**1.6373 %**	**1.6373%**
Steady-State Error (e_{ss})	**0**	**0**	**0**
Peak Time (t_p)	**1.2100**	**1.2100**	**0.1210**
Rise Time (t_r)	**0.56**	**0.56**	**0.0560**

Table 2 Comparison of Fuzzy, GA and hybrid Fuzzy-Genetic controller.

VIII .CONCLUSION

By using Hybrid Fuzzy-Genetic Controller for enhancement of stability and accuracy of the SEDC Motor under the effect of the external disturbances and noise, the speed response for constant load torque shows the ability of the drive to instantaneously reject the perturbation. The design of controller is highly simplified by using a cascade structure for independent control of flux and torque. Excellent results added to the simplicity of the drive system, makes the Hybrid Fuzzy-Genetic Controller based control strategy suitable for a vast number of industrial, paper mills etc. The sharpness of the speed output with minimum overshoot defines the precision of the proposed drive. Hence the simulation study indicates the superiority of Hybrid Fuzzy-Genetic Controller over the Genetic algorithm and Fuzzy logic controller separately. This control seems to have a lot of promise in the applications of power electronics.

After having applied the proposed FLC-GA method we can conclude in this paper, that the use of optimized Fuzzy Logic Controllers is possible to achieve very good results. In particular with this application we are demonstrating statistically that there is significant difference when the controllers are developed manually or automatically. Therefore, with the results presented in the paper we can recommend the use of optimization methods to find some important parameters, in this case, GA was only used to design the optimal topology of the membership functions. However, Genetic Algorithms, Ant Colony Optimization and other approaches could also be used to achieve this goal. Experimental results show better performances that are achieved with the proposed method, optimization with the proposed method FLC-GA, when it is compared with the controllers without optimization.

REFERENCES

[1]. Hénao H., Capolino G.A., Méthodologie et application du diagnostic pour les systèmes électriques, Article invité dans Revue de l'Electricité et de l'Electronique (REE), n°6, pp.79-86. (Text in french), June 2002.

[2]. Raghavan S., Digital control for speed and position of a DC motor, MS Thesis, Texas A&M University, Kingsville, August 2005.

[3]. Yen J., Langari R., Fuzzy logic: Intelligence, Control, and Information, Prentice-Hall, 1999.

[4]. Swarup K.S., Yamashiro S., Unit commitment solution methodology using genetic algorithm, IEEE Trans: Power System, vol. 17, pp. 87–91, 2002.

[5]. Gen M., Cheng R., Genetic Algorithms and Engineering Design, John Wiley and Sons, INC, 1997.

[6]. Belarbi K., Titel F., Genetic Algorithm for the Design of a Class of Fuzzy Controllers An Alternative, IEEE Trans: On Fuzzy Systems, Vol. 8, No. 3 pp. 398-405, 2000.

[7]. Zhou Y. S., Lai L. Y., Optimal Design for Fuzzy Controllers by Genetic Algorithms, IEEE Trans: On Industry Application, Vol. 36, No. 1 pp. 93-97, 2000.

[8]. Hazzab A., Bousserhane I.K., Kamli M., Design of fuzzy sliding mode controller by genetic algorithms for induction machine speed control, International Journal of Emerging Electric Power System, Vol. 01, No. 02, 2004.

[9]. Lee M., Takagi H., Integrating design stages of fuzzy systems using genetic algorithms, Proc. 2nd IEEE Internat. Conf. on Fuzzy Systems, San Francisco, CA, pp. 612-617, 1993.

[10]. Foran J., Optimisation of a Fuzzy Logic Controller Using Genetic Algorithms, Doctorat, Texas University of America, USA, 2002.

[11] Brahim GASBAOUI and Brahim MEBARKI (2009) "Setting Up PID DC Motor Speed Control Alteration Parameters Using Particle Swarm Optimization Strategy" Leonardo Electronic Journal of Practices and Technologies, ISSN 1583-1078, Issue 14, January-June 2009, p. 19-32.

[12] Mehdi Nasri, Hossein Nezamabadi-pour, and Malihe Maghfoori (2007) "A PSO-Based Optimum Design of PID Controller for a Linear Brushless DC Motor " World Academy of Science, Engineering and Technology 26 2007, Manuscript received Jan. 17, 2007.

[13] Z.A. Zadeh, " Fuzzy sets", Information and Control, vol. 8, 1965, pp. 338-353.

[14] S.K. Pal et al., "Fuzzy logic and approximate reasoning: An Overview", Journal of Institution of Electronics and Telecommunication Engineers, Paper No. 186-C,1991, pp. 548-559.

[15] Y.H. Song and A.T. Johns, "Application of fuzzy logic in power systems: Part 1 General Introduction to fuzzy logic", IEE power Engineering Journal, Vol. 11, No. 5, 1997, pp. 219-222.

[16] Y.H. Song and A.T. Johns, "Application of fuzzy logic in power systems: Part 2 Comparison and Integration with expert systems, neural networks, and genetic algorithms", IEE power Engineering Journal, Vol. 12, No. 4, 1998, pp. 185-190

[17] J Nanda and B L Kaul, "Automatic Generation Control of An Interconnected Power System", IEE Proc, vol 125, no 5, May 1978, p 384.

[18] C.S. Indulkar and Baldev Raj, "Application of fuzzy controller to automatic generation control",

Electric machines and power system, vol. 23, No. 2,1995, pp. 209-220.
[19] C.S. Chang and W. Fu, "Area load frequency control using fuzzy gain scheduling of PI controllers", Electric power system research, Vol. 42,1997, pp. 145-152
[20] Q.P.Ha, " A fuzzy sliding mode controller for power sytem load frequency control" in Proc. 1998 second international conference on knowledge based intelligent electronic systems, 21-23 April, pp. 149-154.
[21] G.A. Chown and R.C. Hartman, " Design and Experience with a fuzzy logic controller for automatic generation control" IEEE Transactions on power system, vol. 13, No. 3 August 1998, pp. 965-970.
[22] Jawad Talaq and Fadel Al-Basri, "Adaptive fuzzy gain scheduling for load frequency control" IEEE Transactions on power system, vol. 14, No. 1 February 1999, pp. 145-150
[23] Q.P. Ha and H. Trinh,"A variable structure based controller with fuzzy tuning for load frequency control" International Journal of power and energy systems, vol. 20 No. 3, 2000, pp. 146-154.
[24] M.K. El-Sherbiny, G. El-Saady, Ali M. Yousef, " Efficient fuzzy logic load frequency controller" Energy Conversion and Management, 43, 2002, pp. 1853-1863.
[25] S.P. Ghoshal , " Multi area frequency and tie line power flow control with fuzzy logic based integral gain scheduling" Journal of Institute of Engineers, vol. 84, December 2003, pp. 135-141
[26] E. Yesil, M. Guzelkaya, I. Eksin, " Self tuning fuzzy PID type load and frequency controller" Energy Conversion and Management, 45, 2004, pp. 377-390.
[27] J.R.Kosa, "Genetic programming on the programming of computers y natural selection", MIT press, 1992, Cambridge, MA, USA.
[28] Ibraheem, Prabhat Kumar, D.P. Kothari, " Recent Philosophies of utomatic generation control strategies in power system", IEEE ransactions on power systems, vol. 20, No. 1, February 2005, pp 46-357.
[29] D.G. Goldberg, "Genetic Algorithm in search, optimization and achine learning", Addison –Wesley Publishing Company, 1989.
[30] Mitchell, M., "An Introduction to genetic algorithm", MIT press,1996.
[31] Davis, L. (Editor), "Handbook of genetic algorithm", Van Nostrand Reinhold,1991.
[32] J.T. Alander, J.T., " An indexed bibliography of genetic algorithm in power engineering", Report series 94-1, Power, 21 February 1996, ftp://ftp. Uwasa. Fi/cs/report 94-1/gaPOWER bib.ps.z.
[33] Y.L. Abdel-Magid and M.M. Dawoud, " Genetic algorithms applications in load frequency control" In Proc. Conference on genetic algorithms in engineering systems: Innovation and applications, September 1995, pp. 207-213.
[34] Y.L. Abdel-Magid and M.M. Dawoud, "Optimal AGC tuning with genetic algorithms" Electric Power system Research, No. 38, 1997, pp. 231-238.
[35] Pataya Dangprasert and Vichit Avatchanakorn, "Genetic Algorithms based on an intelligent controller" Expert systems with applications, vol. 10, No. 3 /4, 1996, pp. 465-470.
[36] Li Pingkang, Zhu Hengiun and Li Yuyun, "Genetic algorithm optimization for AGC of multi area power systems" In Proc. 2002 IEEE TENCON, pp. 1818-1821.
[37] S.K.Aditya and D. Das, " Design of load frequency controllers using genetic algorithm for two area interconnected hydro power system" Electrical Power Components and Systems, 31: 2003, pp. 81-94.
[38] Adel Abdennour, "Adaptive optimal gain scheduling for the load frequency control problem" Electrical Power Components and Systems, 30: 2002, pp. 45-56.
[39] D. Rerkpreedapong, Amer Hasanovic, and Ali Feliachi, "Robust load frequency control using genetic algorithms and linear matrix inequalities", IEEE Transactions on Power Systems, Vol. 18, No. 2, May 2003, pp. 855-861.
[40] Chia-Feng Juang and Chun-Feng Lu, "Power system load frequency control with fuzzy gain scheduling designed by new genetic algorithms" In Proc. 2002 IEEE international conference on fuzzy systems, vol. 1, 2002, pp. 64-68.
[41] Byrne, J.P., 2003. GA-optimization of a fuzzy logic controller. Masters Thesis, School of Electronic Engineering, Dublin City University.
[42] Bucci, G., M. Faccio and C. Landi, 2000. New ADC with piecewise linear characteristic: Case study-implementation of a smart humidity sensor. IEEE Trans. Instrument. Measure., 49: 1154-1166. DOI: 10.1109/19.893250.

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