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PERFORMANCE ANALYSIS OF ACO BASED PID CONTROLLER IN AVR SYSTEM

Diksha Bhingardeve[1], Pranav Shinde[2], Nandini Gurav[3], Nikita Gurav[4], Prasad Yadav[5]

Students, Electrical Engineering Department, AITRC, VITA.[1-4]

Project Guide, Electrical Engineering Department, AITRC, VITA.[5]

Abstract: AVR plays a vital role in generating stations. To maintain the voltage stability of the generator the terminal voltage should remain constant. In a large interconnected system, manual regulation is not feasible and therefore automatic generation and voltage regulation equipment is installed at each generator. So, an Automatic voltage regulator (AVR) is used to maintain a constant voltage level and it uses an electromechanical mechanism or electronic components depending on its design. The regulators must be designed in such a way that it is insensitive to very small changes; if this is not happened then the system may be prone to hunting and result in excessive wear and tear in machine and control equipment. This paper consists of simulation and hardware implementation of Ant Colony Optimization algorithm based PID controller design for the automatic voltage regulator. The performance of an AVR system with conventional fixed gain PID controller and ACO algorithm-based PID is compared in a Matlab environment by measuring the settling time, peak overshoot, and oscillation. The proposed system is also analyzed by hardware implementation

Keywords*:* AVR, ACO, PID, etc.

I. INTRODUCTION

In a power system it is very much essential that the system should operate in steady state condition. Steady-state condition means maximum power that can be transmitted without loss of synchronism [44-40]. It is already known that load cycle changes continuously because load is not constant; as it is peak in the morning, lowers in the afternoon section and again increases in the evening [39]. Load changing requirements can be met with help of Excitation Systems. Excitation of system is done manually or automatically. For large interconnected systems manual excitation is not feasible therefore AVR is installed at each generating station [44]. A good quality of the electric power system requires both the frequency and voltage to remain at standard values during operation. Turbine speed governor system is also choice to maintain speed and excitation of system but this system has disadvantage that it requires another supplementary mechanical system e.g. flywheel ball governor [44].

PID controller is one of the Fix gain system but it is not a best solution for AVR system because of fluctuating load and constant gain, which reduces the performance of AVR system. However, in general PID controller is designed for a specific situation and its effectiveness under these particular conditions. Hence, it is desirable to increase the capability of PID controllers to suit the needs of present day applications [37].

In modern systems more than 70% of industrial controller is PID controller. In any system fine tuning of PID controller is vital. In various literatures, many methods are present for fine-tuning PID controllers [37]. Also, automatic tuning methods have been developed and some of the PID controllers may possess on-line automatic tuning capabilities. Advanced forms of PID control, such as I-PD control are currently used in industries. PID controller is used in most control system and their applications where plant mathematical model is not known [3].PID controller improves transient response by reducing settling time and overshoots of system results in performance improvement. Traditionally tuning PID by trial and error method is very tedious and time-consuming. To reduce this complexity, the Evolutionary algorithm technique is used which solves a wide range of practical problems. Evolutionary algorithms like Genetic Algorithm (GA), Simulated Annealing (SA), and Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO) have been employed in control applications to efficiently search global optimum solutions.

II. LITERATURE SURVEY

Surya Prakash *et al.* propose a theory on Load frequency control of interconnected hydro-thermal reheat power system using artificial intelligence and PI controllers. The result reveals that the conventional (PI) and Intelligent control approach improves dynamic response of hydro power station. Combination of most complicated scheme such as hydro electrical and steam power station interconnected obviously increases the non-linearity of system .the performance are simulated by using MATLAB [1]. Mohd. Rozely Kalil, Ismail Musirin (2006) developed Ant Colony Optimization for Voltage control study identify that application of

Ant colony algorithm for searching optimal point for maximum load ability point at load bus and shows that Ant colony optimization technique reduce computational burden on in optimization process [2]. Hamid Boubertakh, Mohamed Tadjine, Pierre-Yves Glorennec and Salim Labiod (2009) in Tuning fuzzy PID controllers using Ant colony optimization reveal that in addition to the conventional tuning methods, the nature inspired algorithms become actually an alternative for tuning PID controllers. Ant colony algorithm finds optimum parameters that minimization of cost of function coding and efficiency illustrated by simulation result [3]. Nazli Madinehi, Kiarash Shaloudegi, Mehrdad Abedi, Hossein Askarian Abyaneh (2011) in optimum design of PID controller in AVR system using intelligent methods in that study two optimization algorithm are used namely shuffled frog leaping and particle swarm optimization this two algoritm are used to determine optimal PID controller in AVR system and also shows that for tuning PID controller using various optimization technique reduces complexity and find more realistic result than trial and error method [5].

Hany M. Hasanien(2013) propose optimization of PID controller in AVR system shows that minimize the maximum percentage overshoot, the rise time, the settling time and oscillation and step response of AVR system can be changed[5]. Narendra Kumar Yegireddy and Sidhartha Panda (2014) on their study of design of PID controller in AVR system this design in this shows that high degree of fine tuning is first priority so that got best result for PID controller and electronic control system for synchronous generator for stable operation [7]. S. Dadvandipour, N. Khalili Dizaji, S. Rosshan Entezar (2015) propose an approach, based on the imperialist competitive algorithm (ICA) and fuzzy logic to optimize the coefficients of PID controller so that more stability and controllability obtain [9]. Haluk Gozde (2010) in performance analysis of artificial bee colony algorithm for AVR system realize that AVR system with better dynamic response, a number of different control strategies such as optimal, adaptive, robust control, etc. have been reported by researchers so far that fine tuning and robustness of control system are extensively investigated [8-11]. S. Panda (2012) on design of PID controller in by using AVR system by overshoot and settling time reduces effectively by using PSO. And PSO also know as Many Optimizing Liaisons (MOL) [13]. Yinggan Tang(2012) in design of fractional order PID controller for AVR system using chaotic ant swarm shows that reduce nonlinear behavior of objective such as settling time, peak overshoot, oscillations[15].

III. ACO-PID CONTROLLER

In control system PID control system is more popular for parameter tuning purpose. The Conventional fixed gain PID controller, this is well known technique for most of industrial control process. The design of this controller requires the three main parameters, namely Proportional gain (Kp), Integral time constant (Ki) and derivative time constant (Kd). This gain of the controller is tuned by trial and error method based on the experience and plant behavior. This process will consume require more time and will be suitable only for particular operating condition means that where fix gain is present or in the other word error value is always remain same at that condition this is used. In this project, ACO algorithm is used to optimize the gains, and the values are transferred to the PID controller of the plant representing AVR of the power generating system as shown in Figure

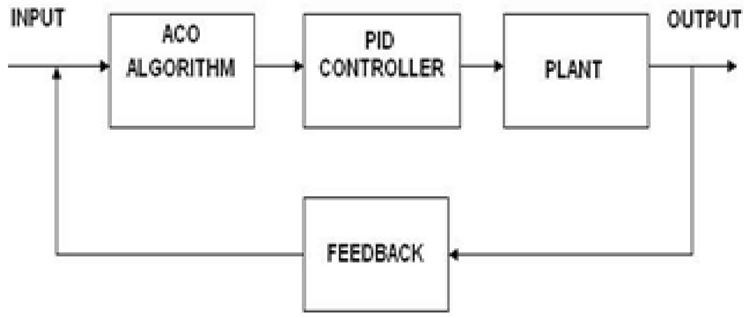

Figure 1: ACO-PID Controller [45]

The proportional gain makes the controller respond to the error value while the integral gain help to eliminate steady state error and derivative gain to prevent overshoot. The plant is replaced by AVR models developed using Simulink in MATLAB.

IV. SIMULATION RESULT

1. Firstly, initialize algorithm parameters like number of iterations and decay rate. Then set the value of Kp, Ki and Kd for furtheroperation randomly from 0.1 to 10 with gradual increment of 1 in its array. Initially all arrays remain blank.

2 .Load all the values such as output array, global array and error array which are initially blank

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3. When loop is initiated at that juncture iterations start building solution incrementally. The values start updating and every time re sults are stored in the output array and finally all the data is stored in global array.

4. After storing these results in the array, now generate error value. Error values are calculated by subtracting output values from set value which are stored in array at every iteration. This loop continues till minimum error value is detected.

5. If maximum iteration is not satisfied then loop repeats itself from the stages 2, 3 and 4 till minimum error value is detected.

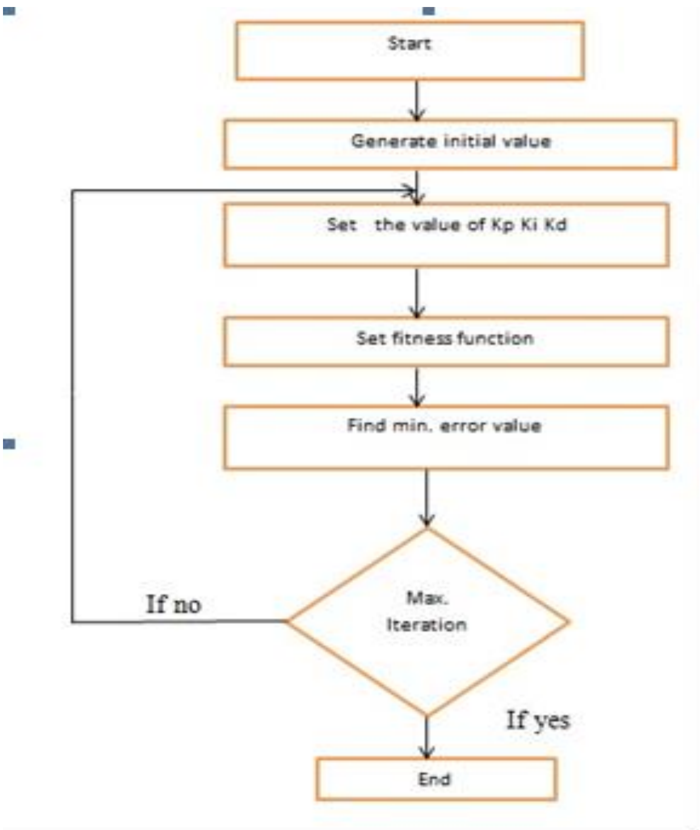

Fig Flow chart of ACO with PID

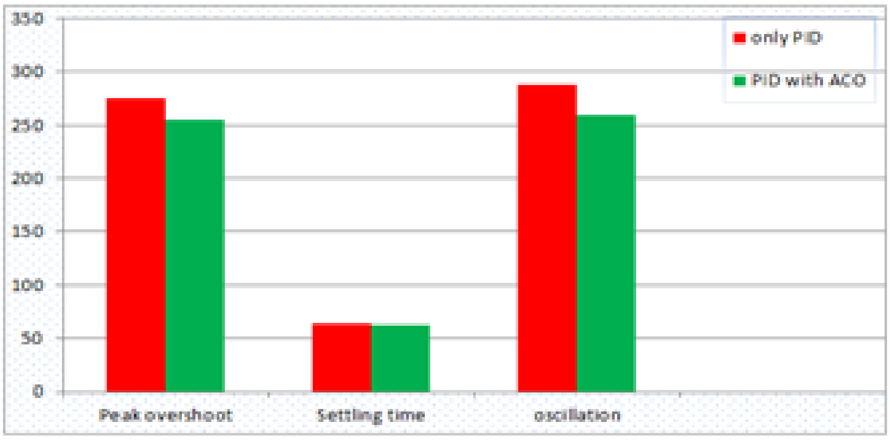

Fig. PID WITH ACO

The above fig shows result of only PID and ACO with PID controller in AVR. Here green line indicates result of ACO with PID controller in AVR system and red line shows PID controller in AVR system. The graph is started from calibrated values of servo motor. Output values of iteration are compared with set point value. Iteration stops when minimum error value is detected. From above performance curves it is understood that by using Ant colony system and PID controller for AVR improves settling time, peak overshoot and oscillation of system. The optimum result is encountered due to pheromone concept of finding shortestpossiblepath to get desired results.

Comparison of output results of both systems sows that all the parameter of control system such as peak overshoot, settling time and oscillation are improved. Hence it proves that by using ANT COLONY ALGORITHM with PID controller in AVR system, performance gets improved. This is graphically represented as below. This gives clear idea of about reduction in performance hindering parameters by using ACO in PID controller. Fig. comparison chart of parameter.

V. HARDWARE IMPLEMENTATION

This chapter introduces Ant colony optimization for PID controller in AVR system. In this prototype two step-down transformers are used. Signal conditioning unit requires small voltage level therefore 230V is converted into 5V. The prominence of ACO is that it gives fine tuning to PID controller in AVR system. ACO gives shortest possible path to get optimum tuning the gain of PID controller. In prototype design the autotransformer connects to servo motor by coupling. Autotransformer is used for buck and boost system. When system voltage is reduced then servo motor senses the error value and it increases the system voltage with the help of autotransformer by changing the angle of autotransformer. When system voltage is increased transformer changes its angle and reduces the voltage level; every time system has to maintain output voltage constant. Servo motor is used for feedback purpose; it gives feedback or senses the error value and accordingly changes their angle. The PWM technique is used to send information to servo motor as servo motor understand the PWM signal. Later in the circuit, analog to digital converter is used because ATMEGA328 IC requires digital signal.

VI. FUTURE SCOPE

This project of PID with ACO used in AVR system may be used in generating station for fine tuning. Because PID has fixed gain so if no algorithms are used then it definitely create error so when it use PID with ACO at that time definitely fine tuning takes place. It may be used where load fluctuation takes place. This technique may also be implemented where stable operation is required. This project will be helpful for where constant voltage is required

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VII. CONCLUSION

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REFERENCES

[1]. S Surya Prakash , S.K. Sinha "Load frequency control of three area interconnected Hydro-thermal reheat power system using artificial intelligence and PI controllers" International Journal of Engineering, Science and Technology Vol. 4, No. 1, 2011, pp. 23-37

[2]. Mohd. RozelyKalil, Ismail Musirin "Ant Colony Optimization for Maximum Load ability Search in Voltage Control Study" First International Power and Energy CoferencePECon 2006 240November 28-29, 2006, Putrajaya, Malaysia.

[3]. Hamid Boubertakh, Mohamed Tadjine, Pierre-Yves Glorennec and SalimLabiod "Tuning Fuzzy PID Controllers using Ant Colony Optimization" 17th Mediterranean Conference on Control & Automation Makedonia Palace, Thessaloniki, Greece June 24 - 26, 2009

[4]. Hwan Il Kang, Min Woo Kwon, Hwan Gil Bae "PID Coefficient Designs for the Automatic Voltage Regulator Using a New Third Order Particle Swarm Optimization"2010 International Conference on Electronics and Information Engineering (ICEIE 2010)

[5]. Nazli Madinehi, Kiarash Shaloudegi, MehrdadAbedi, Hossein Askarian Abyaneh "Optimum Design of PID Controller in AVR System Using Intelligent Methods" IEEE Trondheim PowerTech 2011.

[6]. Hany M. Hasanien,"Design Optimization of PID Controller in Automatic Voltage Regulator System Using Taguchi Combined Genetic Algorithm Method" IEEE SYSTEMS JOURNAL, VOL. 7, NO. 4, DECEMBER 2013.

[7]. Narendra Kumar Yegireddy and Sidhartha Panda "Design and Performance analysis of PID controller for an AVR system using multi-objective non-dominated shorting genetic algorithm II", IEEE conference 2014.

[8]. Haluk GOZDE, M.Cengiz TAPLAMACIOĞLU, Murat ARI "Automatic Voltage Regulator (AVR) Design with Chaotic Particle Swarm Optimization"ECAI 2014 - International Conference – 6th Edition Electronics, Computers and Artificial Intelligence 23 October -25 October, 2014, Bucharest, ROMÂNIA

[9]. S. Dadvandipour, N. KhaliliDizaji, S. RosshanEntezar "An Approach to Optimize the ProportionalIntegral- Derivative Controller System" 2015 16th international Carpathian control conference (ICCC), 95-99.

[10]. S. Bououdena, M. Chadlib, H.R. Karimi "An ant colony optimization-based fuzzy predictive control approach for nonlinear processes" Information Sciences 299 (2015) 143–158

[11]. Haluk Gozde, M.Cengiz Taplamacioglu "Comparative performance analysis of artificial bee colony algorithm for automatic voltage regulator (AVR) system" Journal of the Franklin Institute 348 (2011) 1927–1946.

[12]. Aytekin Bagis "Tabu search algorithm based PID controller tuning for desired system specifications" Journal of the Franklin Institute 348 (2011) 2795–2812.
[13]. S. Panda, B.K. Sahu, P.K. Mohanty "Design and performance analysis of PID controller for an automatic voltage regulator system using simplified particle swarm optimization" Journal of the Franklin Institute 349 (2012) 2609–2625
[14]. Majid Zamani, Masoud Karimi-Ghartemani, Nasser Sadati, Mostafa Parniani "Design of a fractional order PID controller for an AVR using particle swarm optimization" journal of ELSEVIER M. Control engineering practice 17. (2009) 1380-1387
[15]. Yinggan Tang, Mingyong Cui, Changchun Hua, Lixiang Li, Yixian Yang "Optimum design of fractional order PID controller for AVR system using chaotic ant swarm", ELSEVIER, expert systems with applications 39 (2012) 6887-6896.
[16]. Archway Sakthivel, P. Vijayakumar, A. Senthilkumar, L. Lakshminarasimman, S. Paramasivam "Experimental investigations on Ant Colony Optimized PI control algorithm for Shunt Active Power Filter to improve Power Quality" ELSEVIER, control engineering practice 42 (2015) 153-169.
[17]. Derong Liu, MengChu Zhou "Optimum Design of Fractional Order PID Controller for an AVR System Using an Improved Artificial Bee Colony Algorithm"Acta Automatica Sinica Vol.40, No.5 May, 2014
[18]. Mouayad A. Sahib, "A novel optimal PID plus second order derivative controller for AVR system" Engineering Science and Technology, an International Journal ELSEVIER 18 (2015) 194-206.
[19]. Surya Prakash, S.K. Sinha "Load frequency control of three area interconnected hydro thermal reheat power system using artificial intelligence and PI controllers" International Journal of Engineering, Science and Technology Vol. 4, No. 1, 2011, pp. 23-37.
[20]. Alireza Abbasy,Seyed Hamid Hosseini "Ant Colony Optimization-Based Approach to Optimal Reactive Power Dispatch: A Comparison of Various Ant Systems" IEEE PES Power Africa 2007 - Conference and Exhibition Johannesburg, South Africa, 16-20 July 2007.
[21]. Hany M. Hasanien, IEEE Design Optimization of PID Controller in Automatic Voltage Regulator System using Taguchi Combined Genetic Algorithm Method" IEEE SYSTEMS JOURNAL, VOL. 7, NO. 4.
[22]. A. A. Abou El-Ela • A. M. Kinawy • R. A. El-Sehiemy • M. T. Mouwafi "Optimal reactive power dispatch using ant colony optimization algorithm" Springer, Elect. Engg (2011) 93:103–116.
[23]. Vivek Kumar Bhatt1, Dr. Sandeep Bhongade "Design Of PID Controller In Automatic Voltage Regulator (AVR) System Using PSO Technique", International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 3, Issue 4, Jul-Aug 2013, pp.1480-1485
[24]. A. A. Abou El-Ela, A. M. Kinawy and M. T. Mouwafi, R. A. El Sehiemy "Optimal Reactive Power Dispatch Using Ant Colony Optimization Algorithm" Proceedings of the 14th International Middle East Power Systems Conference (MEPCON'10), Cairo University, Egypt, December 19-21, 2010.
[25]. Shyh-Jier Huang "Enhancement of Hydroelectric Generation Scheduling Using Ant Colony System Based Optimization Approaches" IEEE TRANSACTIONS ON ENERGY CONVERSION, VOL. 16, NO. 3, SEPTEMBER 2001.
[26]. Ying-Tung Hsiao, Cheng-Long Chuang "Ant Colony Optimization for Designing of PID Controllers" 2004 IEEE lntemational Symposium on Computer Aided Control Systems Design Taipei, Taiwan, September 24,2004
[27]. Hamid Boubertakh, Mohamed Tadjine, Pierre-Yves Glorennec and Salim Labiod "Tuning Fuzzy PID Controllers using Ant Colony Optimization" 17th Mediterranean Conference on Control & Automation Makedonia Palace, Thessaloniki, Greece June 24 - 26, 2009.
[28]. Yibao Chen, Zhong Guo, Jiaguang Liu "An Improved Ant Colony Algorithm for PID Parameters Optimization" 2009 Second International Conference on Intelligent Computation Technology and Automation
[29]. Yan Zhao, Zhongjun Xiao, Jiayu Kang "Optimization Design Based on Improved Ant Colony Algorithm for PID Parameters of BP Neural Network" 2010 2nd International Asia Conference on Informatics in Control, Automa
[30]. Hirotaka Yoshida and Yoshikazu Fukuyama "PSO for reactive power and voltage control considering voltage stability" IEEE Trans. on Power Systems, Vol.15, No.4, pp.1232-1239, November 2001.
[31]. Zwe-Lee Gaing, "A Particle Swarm Optimization Approach for Optimum Design of PID Controller in AVR System", IEEE Transactions on Energy Conversion, Vol. 19, No.2, June 2004, pp384-391.
[32]. Hai-bin, Wang Dao-bo, Yu Xiu-fen, "Novel Approach to Nonlinear PID Parameter Optimization Using Ant Colony Optimization Algorithm", Journalof Bionic Engineering 3, pp.073-078, 2006. Duan
[33]. Rohit Kumar Pancholi "Particle Swarm Optimization for Economic Dispatch with Line flow and Voltage Constraints" optimal operations of power system, IEEE Transactions 2003.
[34]. M. S. Yousuf, H. N. Al-Duwaish and Z. M. Al-Hamouz, "PSO Based nonlinear Predictive Control of Single Area Load Frequency Control", IFAC Conference on Control Applications of Optimization, IFAC-CAO-2009, Agora, Finland, May 6-8, 2009.
[35]. Ying-Tung Hsiao, Cheng-Long Chuang and Cheng-Chih Chien "Ant Colony Optimization for Designing of PID Controllers" 2004 IEEE lntemational Symposium on Computer Aided Control Systems Design Taipei, Taiwan, September 24,2004
[36]. Marco Dorigo and Thomas Stutzle "Ant colony optimization", Library of Congress Cataloging-in-Publication Data
[37]. K. Ogata "Modern Control Engineering" New Jersey; Prentice –Hall, Tehran; Aeizh,2002
[38]. Hadi Saadat "Power system analysis", McGraw-Hill Series in Electrical and Computer Engineering 3rd edn, 1997.
[39]. V. K. Mehta "Principle of Power System" S. Chand Publication New Delhi.1st edn, 1982.
[40]. P. Kundur "Power System Stability and Control" McGraw-Hill Companies Schaurns, New York
[41]. J.B.Gupta "Theory and performance of Electrical Machinery " Katariya and sons, New Delhi. 15th edn.
[42]. M .D. Singh, K B Khanchandani "Power Electronics", The McGraw-Hill Companies New Delhi. 2nd edn.
[43]. Ramesh Gaonkar "Microprocessor Architecture, Programming, and Application with 8085" The McGraw-Hill Companies New Delhi. 2nd edn.
[44]. D P Kothari and I J Nagrath "Modern Power Systems Analysis", Tata McGraw-Hill. New York.3rd edn, 1997.
[45]. Shodhganga a reservoir of Indian theses chapter 5"PSO and ACO based PID controller" dated 2013-07-11 pages 128 to 168