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BBO Tuned FLC for Three Phase Rectifier

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***Abstract*—*Three Phase Rectifier in the power electronic system which used in many applications. Optimal for in Power Electronic System control strategy has been proposed for BBO-FLC based Three Phase Rectifier in Power Electronic System. Proposed Power Electronic System (PES) consists of input, isolation and output stages. In order to test dynamic performance of BBO-FLC based PES, simulation study was carried out by MATLAB/Simulink. The results obtained from the BBO-FLC based PES are not only superior in the rise time, settling time and overshoot but can prevent from voltage and has improved power quality. Embody for simulation of Fuzzy Logic Controller and he characterizes to obtain the optimal parameters of FLC. Biogeography Based Optimization BBO is a new intelligent technique for optimization, it can be used to tune the parameters in different fields. The main contribution of this work efforts the ability of BBO to design the parameters of FLC by determining the shapes of triangle memberships of the inputs and output. The results of optimal controller (BBO-FLC) compared with the other controllers designed by Genetic Algorithm GA which it is a powerful method has been found to solve the optimization problem. The implementation of BBO algorithm has been done by M-file/Matlab, this program linked with SIMULINK to calculate the finesses function which has the complete mathematical system model has implemented using. The results show the excellent performance of BBO-FLC compared with GA-FLC and PI controller, also the proposed method was very fast and need a few number of iterations.*

***Keywords*—** *Biogeography-Based Optimization BBO, Fuzzy Logic controller FLC, PI controller and Rectifier.*

I. Introduction

The optimum performance, there are many intelligent optimization techniques have been emerged and get a great attention of researchers like Genetic Algorithm (GA), Particle Swarm Optimization (PSO) techniques bee colony optimization (BCO), Ant Colony Optimization (ACO), Simulated Annealing (SA), and Bacterial Foraging (BF) . Usually GA has a most algorithms founded in the control field, like the search for optimal parameters of FLC controller. But it still requires enormous computational effort. In this paper we suggest a new computational theory named (Biogeography-Based Optimization BBO) to tune parameters of FLC controller. This controller can govern a non-linear system [1]. The tangible benefit of choosing controller is its simplicity to implement. It is not easy to find another controller with such a simple structure to be comparable in performance. Fuzzy rule-based models are easy to comprehend because it uses linguistic terms and the structure of if-then rules [2], [3]. A way controller (PI) in addition to the controller integral relative formulated and implemented, using speed control drive system and a pilot phase. While the new strategy promotes traditional PI control performance to a large extent, and proves to be a model-free approach completely, it also keeps the structure and features of a simple PI controller [4-5]. The use consoles mode instead of Fuzzy-PI control to improve the performance of Three Phase PWM Rectifier. Proportion-integral (PI) controller three Phase PWM Rectifier because of mechanical resonance. As a result, performance degradation and three Phase PWM Rectifier control. It has been adopted and fuzzy logic controller (FLC) for use to improve the performance of the three Phase PWM Rectifier control. The proposed FLC has been compared with traditional PI control with respect to the three Phase PWM Rectifier of response [6-7]. Simulation and experimental results have proved that FLC was proposed is superior to the traditional PI. This FLC can be a good solution for the high-performance three Phase PWM Rectifier systems. A modern approach to control the output of three Phase PWM Rectifier using Biogeography-Based Optimization BBO to improve the algorithm parameters observer PI-. Simulate the system under different operating year conditions is prepared and the experimental setup. Use BBO algorithm and optimization make a powerful three Phase PWM Rectifier, with faster response and higher resolution dynamic and sensitive to load variation.

II. Power Electronic

Power electronic converter include four types, rectifier (AC-DC), inverter (DC-AC), and converter (DC-DC or AC-AC). The power electronic device is building by using diode, thyristor, insulated gate bipolar transistor IGBT, and …etc. Grid side (three phase AC source), in this part the system get its power by many sources like diesel generators systems, wind turbines generators systems, photovoltaic generators systems and…etc. Following in Figure 1. Source connected machine by power electronic converter, Figure 2.Source connected with diode rectifier for AC-DC-AC conversion, Figure 3. Source connected with IGBT rectifier for AC-DC-AC conversion and Figure 4. Source connected with thyristor rectifier for AC-DC-AC conversion. The output of the switches gives (Vao, Vbo, Vco) then the three phases to load neutral (Van,Vbn,Vcn) can be achieved by implementing equation (1).

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \frac{1}{2} \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix} \begin{bmatrix} V_{ao} \\ V_{bo} \\ V_{co} \end{bmatrix} \tag{1}$$

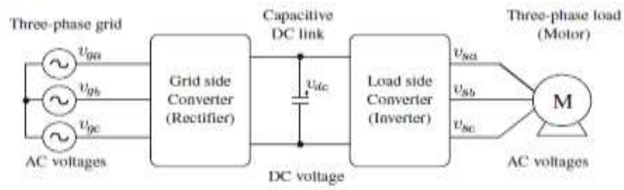

Fig. 1. Source connected machine by power electronic converter.

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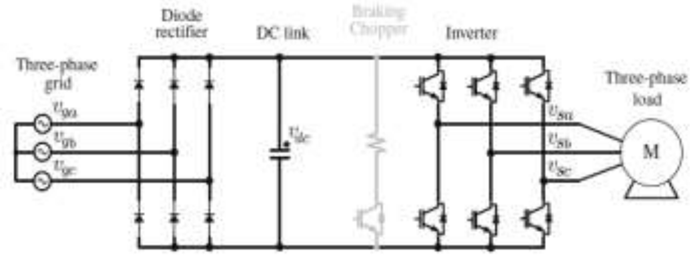

Fig. 2. Source connected with diode rectifier for AC-DC-AC conversion.

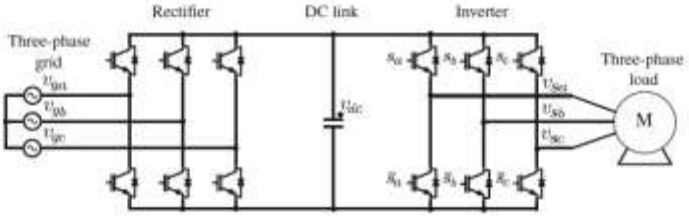

Fig. 3. Source connected with IGBT rectifier for AC-DC-AC conversion.

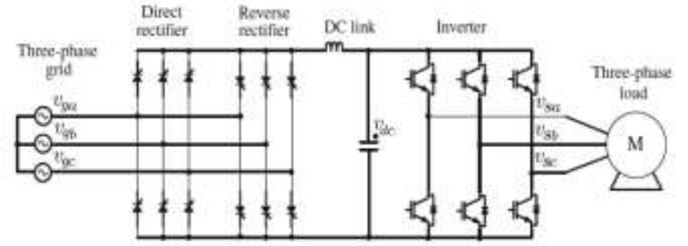

Fig. 4. Source connected with thyristor rectifier for AC-DC-AC conversion.

III. OPTIMIZATION AND CONTROLLER

Optimization and Controller (Classical controller type PI Controller, Expert System type FLC and Optimization type and BBO), Electric system Load is formulated by the RLC. By using control to suppress harmonic noise to a level. Then, noise to a level below and vibration translates into a more comfortable ride for passengers. Source connected with IGBT rectifier for AC-DC conversion (IGBT, PWM rectifier) make the result with frequency and voltage regulation. It has the latest low-noise power units to make the result optimal performance. Load system has directed energy reform in the application geared for small rise because travel extremely small and fast.

IV. BIOGEOGRAPHY-BASED OPTIMIZATION

Inspired of biogeography Simon developed a new approach called Biogeography-Based Optimization (BBO) in (2008). This algorithm is an example of how a natural process can be modeled to solve optimization [8]. In n BBO, each possible solution is an island and their features that describe habitability are named Habitat Suitability Index (HSI). The goodness of each solution is named Suitability Index Variables (SIV). For example of the natural process, why some islands may lean towards to accumulate many more species than others? Because of possess certain environmental features that are more suitable to sustaining that kind than other islands with fewer species. It is axiomatic the habitats with high HSI have large populations, also high immigration rate and by feature of a large number of species that migrate to other habitats. The rate of immigration will be lower if these habitats are already saturated with species. On the other hand, habitats with low HSI have high immigration and low immigration rate, because of the sparse population.

The fitness function FF is associated with each solution of Biogeography-Based Optimization BBO, which is analogous to HSI of a habitat. A good solution is analogous to a habitat having high HSI and a poor solution represents a habitat having a low HSI. The best solutions share their geographies of the lowest solutions throw migration (emigration and immigration). Best solutions have more resistance to change than lowest solutions. While the lowest solutions have more change from time to time and accept many new features from best solutions. The immigration rate and emigration rate of the jth island may be formulated as follows in equation 2, 3 [9].

$$\lambda_i = I(1-\frac{j}{n}) \tag{2}$$

$$\mu_i = \frac{E.j}{n} \tag{3}$$

Where: μ, λj are the immigration rate and the emigration rate of j individual; I is the maximum possible immigration rate; E is the maximum possible emigration rate; j is the number of species of jth individual; and n is the maximum number of species. Jth in BBO, the mutation is used to increase the diversity of the population to get the best solutions.

Mutation operator modifies a habitat's SIV randomly based on mutation rate. The mutation rate mj is expressed in (4).

$$m_j = m_{\max}(\frac{1-p_j}{p_{\max}}) \tag{4}$$

Where mj is the mutation rate for the jth habitat having a j number of species; mmax is the maximum mutation rate; Pmax is the maximum species count probability; Pj the species count probability for the jth habitat and is given by equation (5):

$$\dot{P} = \begin{cases} -(\lambda_j+\mu_j)P_j + \mu_{j+1}P_{j+1}, & j \le 0 \\ -(\lambda_j+\mu_j)P_j + \lambda_{j-1}P_{j-1} + \mu_{j+1}P_{j+1}, & 1 \le j \le n \\ -(\lambda_j+\mu_j)P_j + \lambda_{j-1}P_{j-1}, & j = n \end{cases} \tag{5}$$

Where μj+1, λj+1 are the immigration and emigration rate for the jth habitat contains j+1 species; μj-1, λj-1 are the immigration and emigration rate for the jth habitat contains j-1 species.

V. BBO ALGORITHM OPTIMIZATION

The different steps of the BBO algorithm can be summarized as follows:

Step 1. Generation of initial random set of habitats according to the operating constraints i.e., equality and inequality constraints of the problem. The SIVs of the habitats are randomly generated between their minimum and maximum limits to produce random initial population sets.

Step 2. Evaluation of the fitness (HSI) of each habitat.

Step 3. Sorting of habitats from best to worst. The habitat, which produces the finest value of the objective function, will have best HSI.

Step 4. Identification of elite habitats based on the HSI values.

Step 5. Mapping of HSI to the number of species.
Step 6. Modification of each habitat with the probabilistic migration operation using an immigration rate and emigration rate of each habitat.
Step 7. Modification of habitats with probabilistic mutation operation. Based on the habitat's probability of existence, few probabilistically selected SIVs of a habitat are modified.
Step 8. Verification of the feasibility of the newly generated solution, i.e., each control variable of the new solution must lies within its operating limits.
Step 9. Replacement of infeasible solutions (i.e., the solutions which violate the operating constraint limits) by best feasible solutions
Step 10. Go to step 2 for the next iteration until a stopping criterion be achieved. Stopping criterion is reached when iterations exceed maximum iteration.

VI. IMPLEMENTING BBO TUNING FOR FLC PARAMETERS

The implementation of BBO in this work is same what complex, because the performance of the system must be examined in each iteration and particles position during the optimization algorithm. Therefore, the optimization algorithm is implemented by using MATLAB m-file program and linked with the system simulation program in MATLAB SIMULING, to check the system performance in each iteration. In this paper, the problem summarized in optimizing three variables, they are: one output and two inputs (current and the change in current), each one has three dimensional spaces, represented as the prams of the triangle memberships of FLC. A random of 100, Habitats were assumed and optimization algorithm of 100 iterations is used to estimate the optimal values of the FLC controller parameters. The fitness function FF which illustrated in equation (6).

$$FF = ITSE = \int_0^t t * e^2(t)dt \qquad (6)$$

VII. ADVANCED IMPLEMENTATION FOR THREE PHASE PWM RECTIFIER

To use different control systems, like Classical PI Controller, Expert System Fuzzy Logic Controller and Optimization by GA or BBO. It used to control for Implementation for Three Phase PWM Rectifier. The simulation model as shown in figures (5-8), by used all types to get the result and analysis it with compared to see the advanced implementation for three phase PWM rectifier:

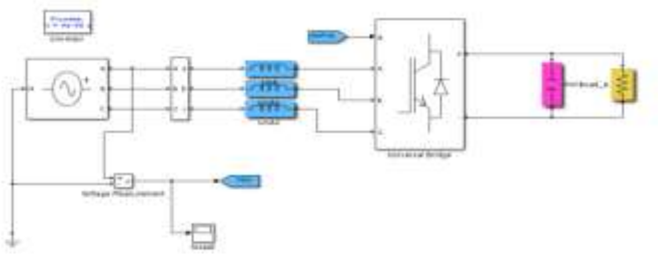

Fig. 5. The simulation model for three phase PWM rectifier.

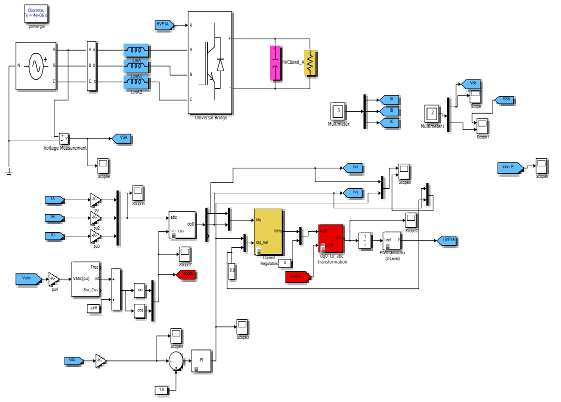

Fig. 6. The simulation model for three phase PWM rectifier with PI control.

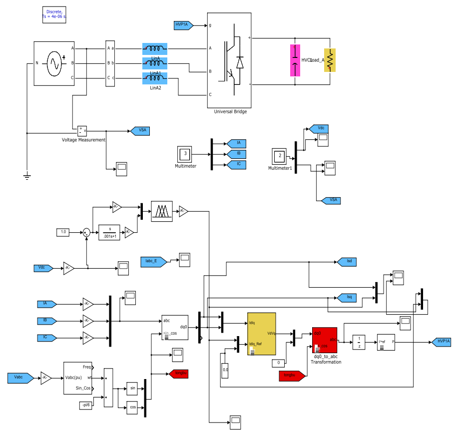

Fig. 7. The simulation model for three phase PWM rectifier with Fuzzy control.

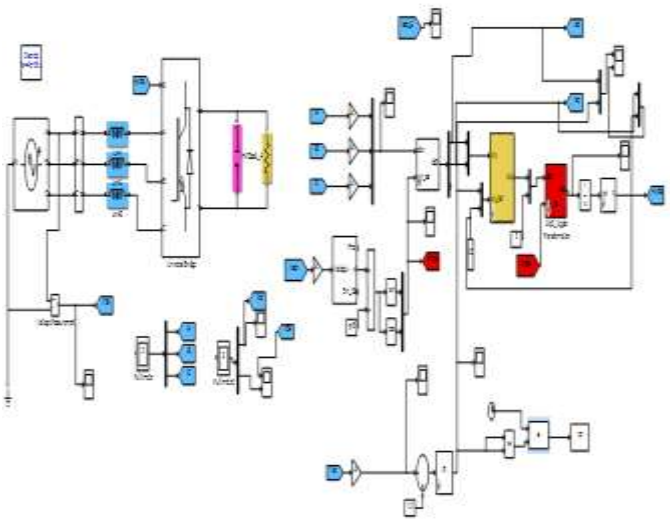

Fig. 8. The simulation model for three phase PWM rectifier with BBO-PI control.

VIII. RESULTS

A. The Simulation Results for Three Phase PWM Rectifier with Controller

By used the simulation model for three phase PWM rectifier with PI control to get the simulation results for three phase PWM rectifier with controller in figures (9-11).

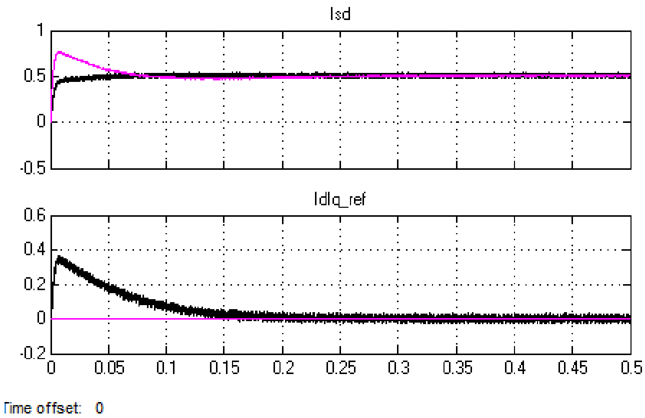

Fig. 9. The Isd & IdIq_ref wave form for three phase PWM rectifier.

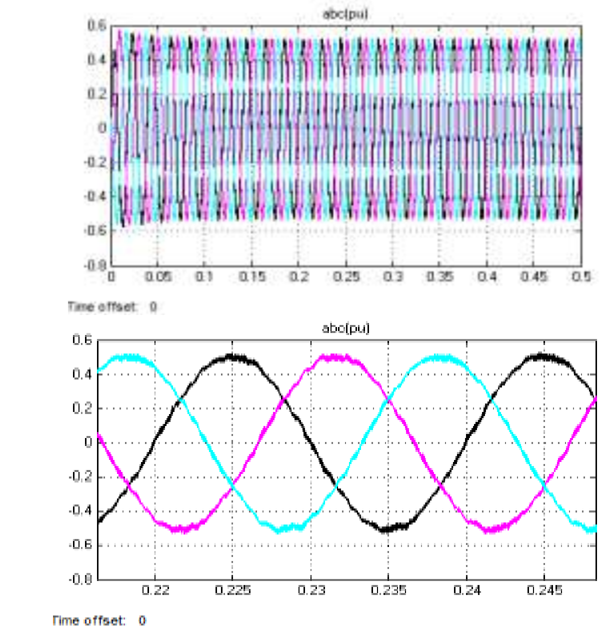

Fig. 10. The abc(pu) wave form for three phase PWM rectifier with controller.

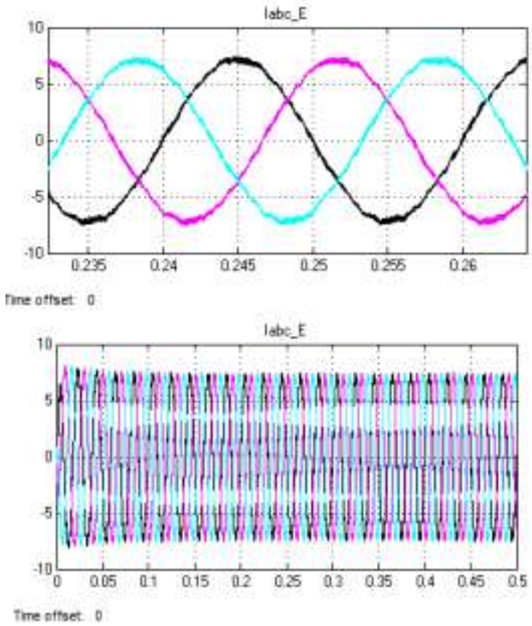

Fig. 11.The Iabc_E wave form for three phase PWM rectifier.

B. The Simulation Results for Three Phase PWM Rectifier with Optimization

By used the simulation model for three phase PWM rectifier with Optimization to get the simulation results for three phase PWM rectifier with Optimization in figures (12-15).

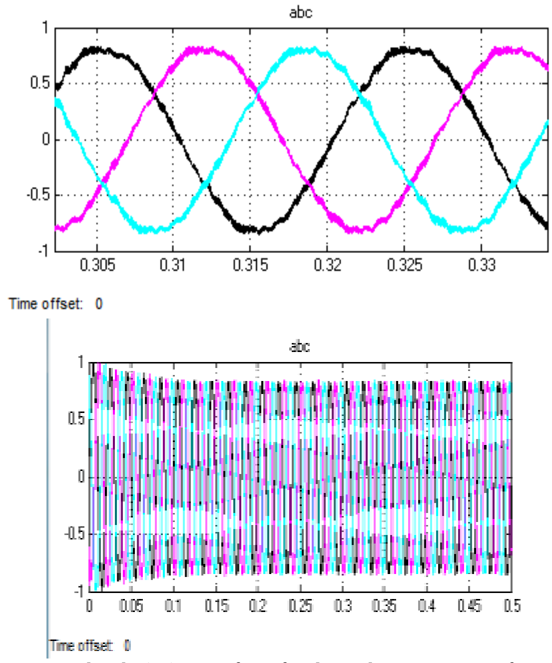

Fig. 12. The abc(pu) wave form for three phase PWM rectifier with optimization.

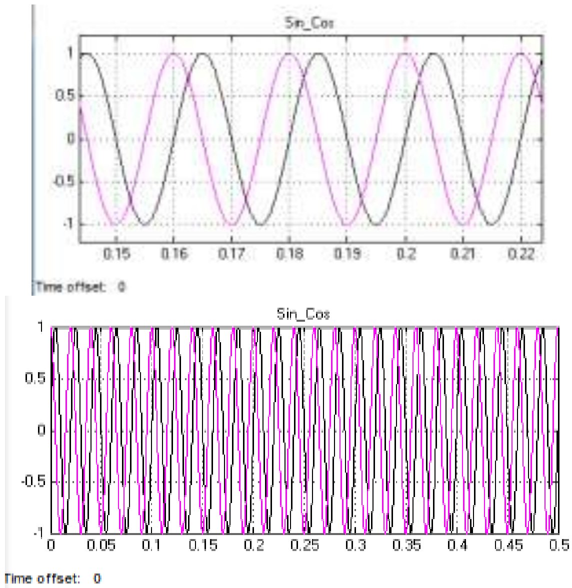

Fig. 13. The sin_cos wave form for three phase PWM rectifier.

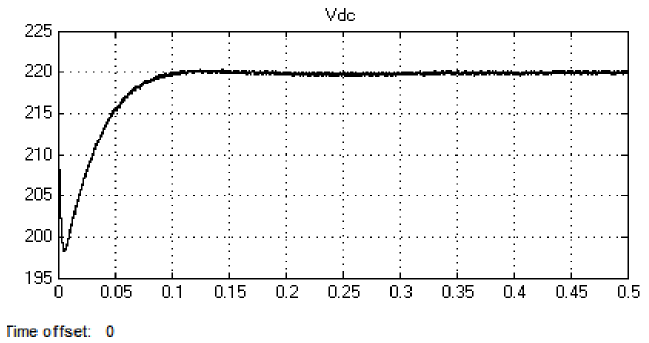

Fig. 14. The Vdc (volt) wave form for three phase PWM rectifier.

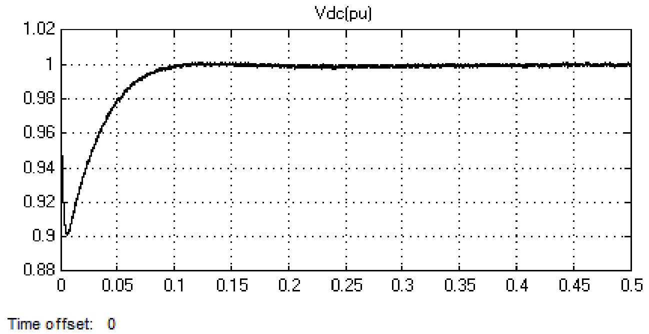

Fig. 15. The Vdc (pu) wave form for three phase PWM rectifier.

Figure 16 shows the convergence of Fitness Function in 100 iterations and the comparison between GA and BBO. Figure 17, 18 the step response with load and no load using proposed controller and GA-FLC and PI-controller tuned by conventional method trial and error. Figure 19 shows FLC designed by BBO and figure 20 shows the surface of FLC.

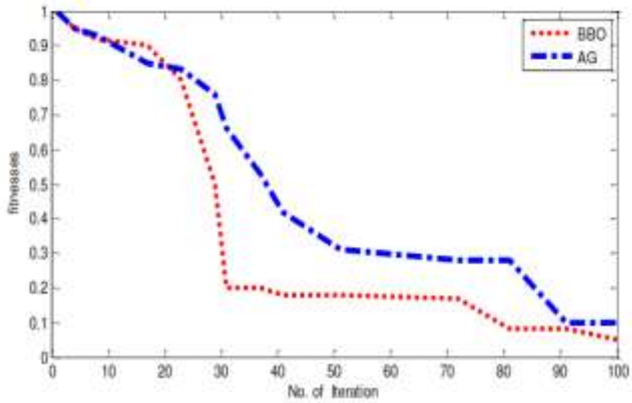

Fig. 16. The convergence of fitness function in 100 iterations.

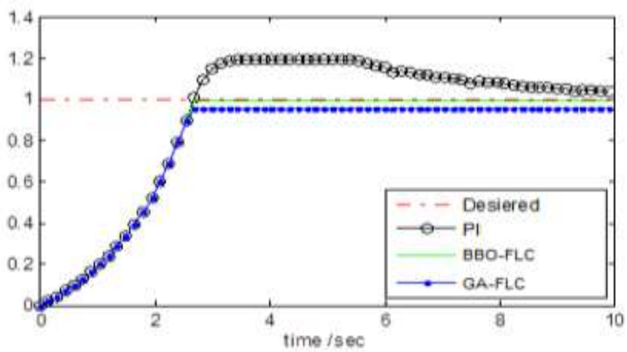

Fig. 17. Step response OF load in different controllers, GA-FLC and BBO-FLC and PI controller.

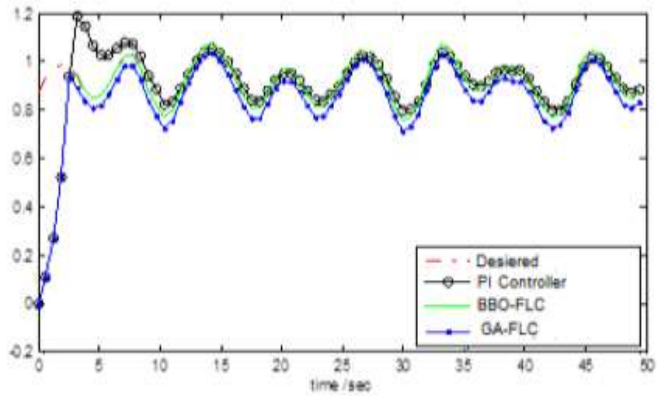

Fig. 18. An arbitrary load between (1.1pu and 0.7pu).

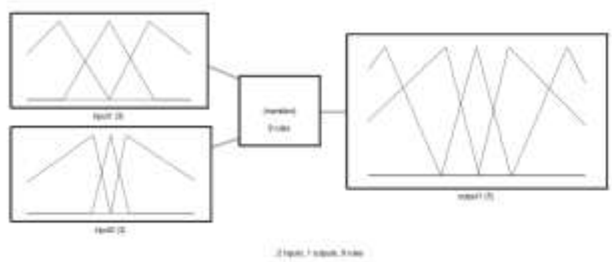

Fig. 19. FLC memberships designed by BBO.

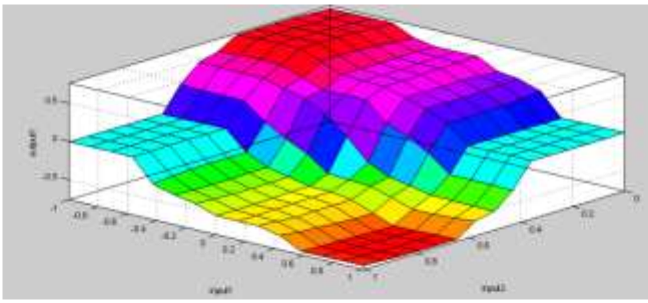

Fig. 20. The surface of FLC designed by BBO.

IX. CONCLUSION

The system responses of different tuning methods are illustrated in simulation result and a comparable performance between the three controllers in this research (PI controller, GA-FLC and BBO-FLC) as shown in figures (17-18). We find the optimized BBO-FLC is closed with desired speed and its performance is the best compared with GA-FLC and PI controller.

We can obtain the following conclusions through simulation analysis:

1-This paper design fuzzy logic control by computational algorithm, it interject Control concepts of trial and error in fuzzy control and conventional GA-FLC method.

2- Obviously, the BBO tuning of the FLC is the best intelligent method which gives an excellent system performance, and the GA gives a good response with respect to the traditional trial and error method.

3- In addition to the improving of system response, the BBO and GA can use a higher order system in the tuning process which avoids the error of system order reduction. It gave a satisfactory solution during the first 30 iterations as shown in figure (16).

4- The proposed method makes control system have strong flexibility, instantaneity and reliability because of the advanced prediction of FLC predicting controller

5- It makes control system have stronger Real-time controller ability because of optimal fuzzy parameters have ahead predict for a possible interfere source. The lower interference frequency, BBO algorithm is more controllable.

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