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Optimization of fuzzy inference system based on particle swarm optimization to enhance the efficiency of system

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Abstract

In this method, new approach for hybrid system based on fuzzy inference system FIS and Particle Swarm Optimization (PSO) for enhancement of nonlinear system was proposed. In this hybrid artificial intelligence, the proposed FIS-PSO is applied to remove the drawbacks of electronic system in aircraft. The main weakness of electronics nonlinear system of aircraft is that the response of system is very slow, distorted current and voltage, and low efficiency. The FIS is used to control the system performance and PSO is used to optimize the FIS by adjusting membership functions MMF of FIS by present best value pbest and global best values of each particle. The update velocity and position are used to limit and optimize the MMF and to modify the target system. The simulation is built by using Matlab Simulink toolbox. The simulation results show that the performance of FIS-PSO could be more significant and has the authority over classical FIS.

1 Introduction

Fuzzy inference system and Particle swarm optimization are one of Artificial Intelligence (AI) which are used to solve the complicated of nonlinear system. The fuzzy inference system depends on human experts, which consists

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of fuzzification, knowledge database, inference rules, and defuzzification parts the logic will applied on behalf of the Boolean logic to control the system. This structure is assumed to solve problems, wherever that is no mathematical model for system, and the system drawbacks can be solve via experts in the rules and membership functions of FIS [1], [2] [3]. A fuzzy system can be suitably applied to the solve problem, which depend on human expert based on try and error [4][5][6] . The artificial intelligence system based on FIS and PSO also applied in nonlinear system to increase the system efficiency [7][8][9].

Many researchers proposed a lot of methods to enhance the system performance by using fuzzy inference system with particle swarm optimization [10][11]. In addition, the authors in [12][13][14][15] optimize the system performance with high efficiency but the system was more complicated and slow response.

The main target of this method is to control the electronics system of aircraft via FIS and the PSO is used to increase speed response of system by optimize the MMF of FIS. The rest of this paper is organized as section 2 demonstrates the FIS and particle swarm optimization. In addition, the proposed method with discussion of results will discuss in section 3. Finally, section 4 will discuss the conclusion of the proposed method.

2 Fuzzy inference system with particle swarm optimization

Fuzzy Inference Systems was discovered by lotfi zada in 1965 which is applied to the system that has no mathematical model and it used the system and process them by rules to product the outputs. The fuzzy inference systems are two types one of them is mamadani and another sugeno. The output of mamadani is nonlinear and the output of sugeno is linear. FIS consists of fuzzification, set system, rules with membership functions, and defuzzification.

In addition, particle swarm optimization (PSO) was discovered in 1995 which is an optimization method that modifies the system weakness by irritating to progress a solution with respect to a specified measure of superiority. It used to solve a problem system by random population, and initialize each particle with position and velocity. Each particle has a local and global best position. This is estimated to transfer the swarms to the best answers.

3 Proposed Method

The hybrid suggested FIS -PSO method are used to enhance the performance of the nonlinear electronic system for the aircraft. In this proposed method, FIS is used to control the system via triangular membership functions MMF and the number of rules. The PSO is applied the random populations to produce the fitness function of system by obtaining present best p_{best} and g_{best} of each particle as results to select output optimal position for MMF. The flow chart of hybrid FIS-PSO is shown in Figure1 . The proposed update velocity is shown in equation(1).

$$v_{i_{(t+1)}} = wv_{i(t)} + c_1 r_1 (x^{-}_{i(t)} r_1 - x_{i(t)}) + c_2 r_2 (g_{(t)} - x_{i(t)}) + v_{i(t)} MMF_{i(t)} \quad (3.1)$$

The update position of each particle can be calculated by the equation 2

$$x_{i(t+1)} = x_{i(t)} + v_{i(t+1)} MMF_{(t+1)}, \quad (3.2)$$

where w is the inertia coefficient, c_1,c_2 are the acceleration coefficient, r_1,r_2 are the random values, v_i is the velocity of each particles, $x_{i(t)}$ is the particles position, $x^{-}_{i(t)}$ is best solution of particle's individual, $g_{(t)}$ is the best solution of swarm The rules viewers, structure, and MMF of FIS are shown in figure 2,figure 3, and figure 4 respectively. From Figure 3, the two inputs of FIS are speed and error of system speed but the outputs are DC System with error of DC system.

The best population and mean population of PSO are shown in figure 5. It can be seen that random population are 2000 particles and 150 iterations to evaluate the fitness function of MMF.

The global best position for each particle to select the MMF is shown in figure 6.

The suggested hybrid FIS-PSO applied to optimize the performance of electronic system of aircraft as shown in next figures. From figure 7 and figure 8, the current and voltage of system are smooth with low distortion as

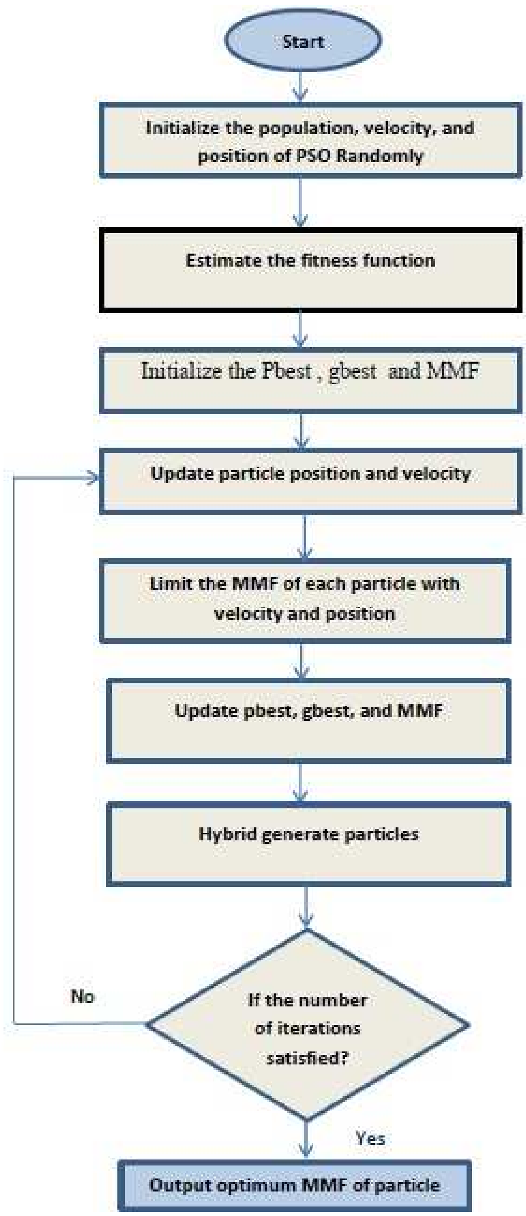

Figure 1: flow chart of proposed FIS-PSO

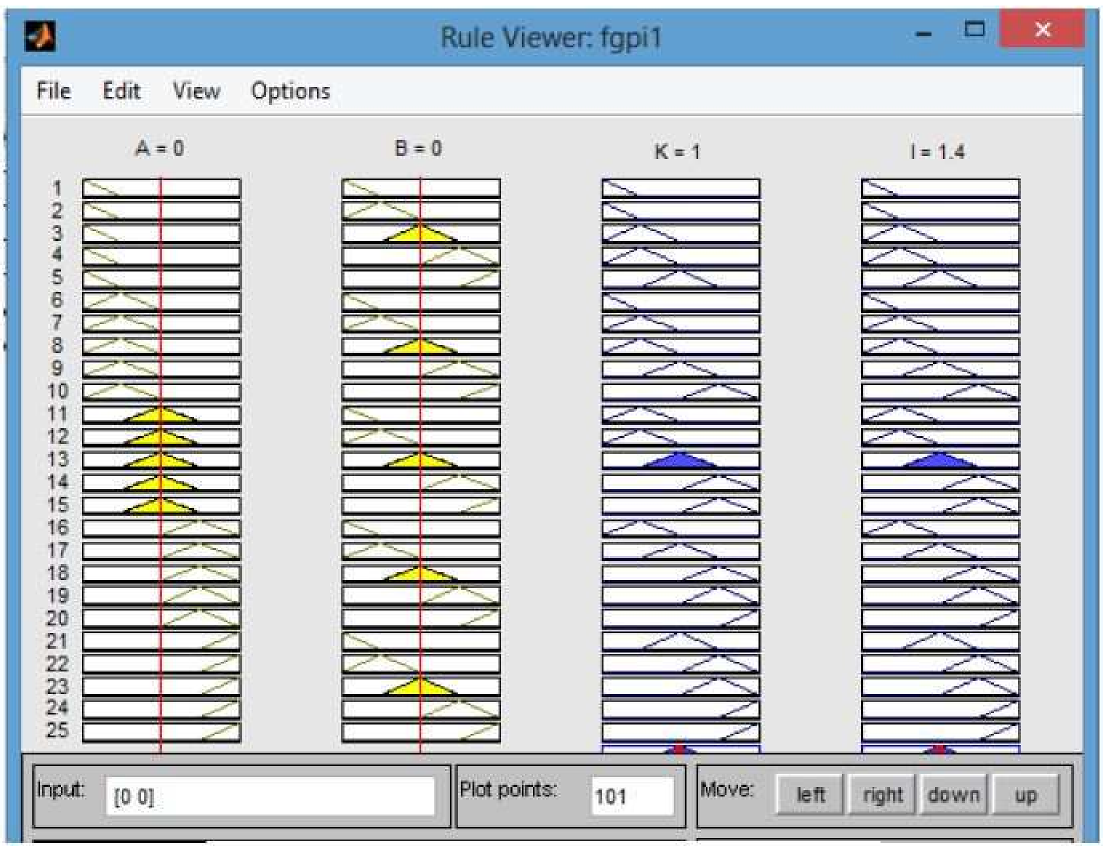

Figure 2: Rules viewers of FIS

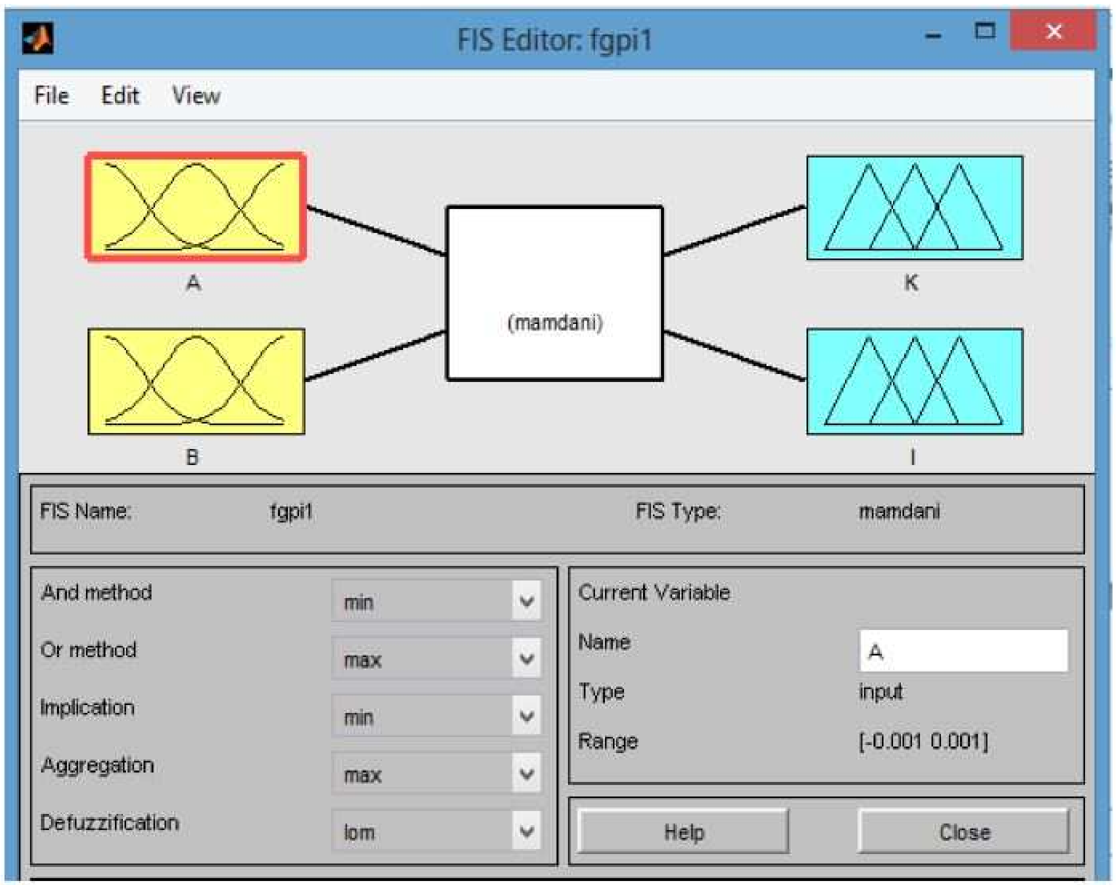

Figure 3: Structure of FIS

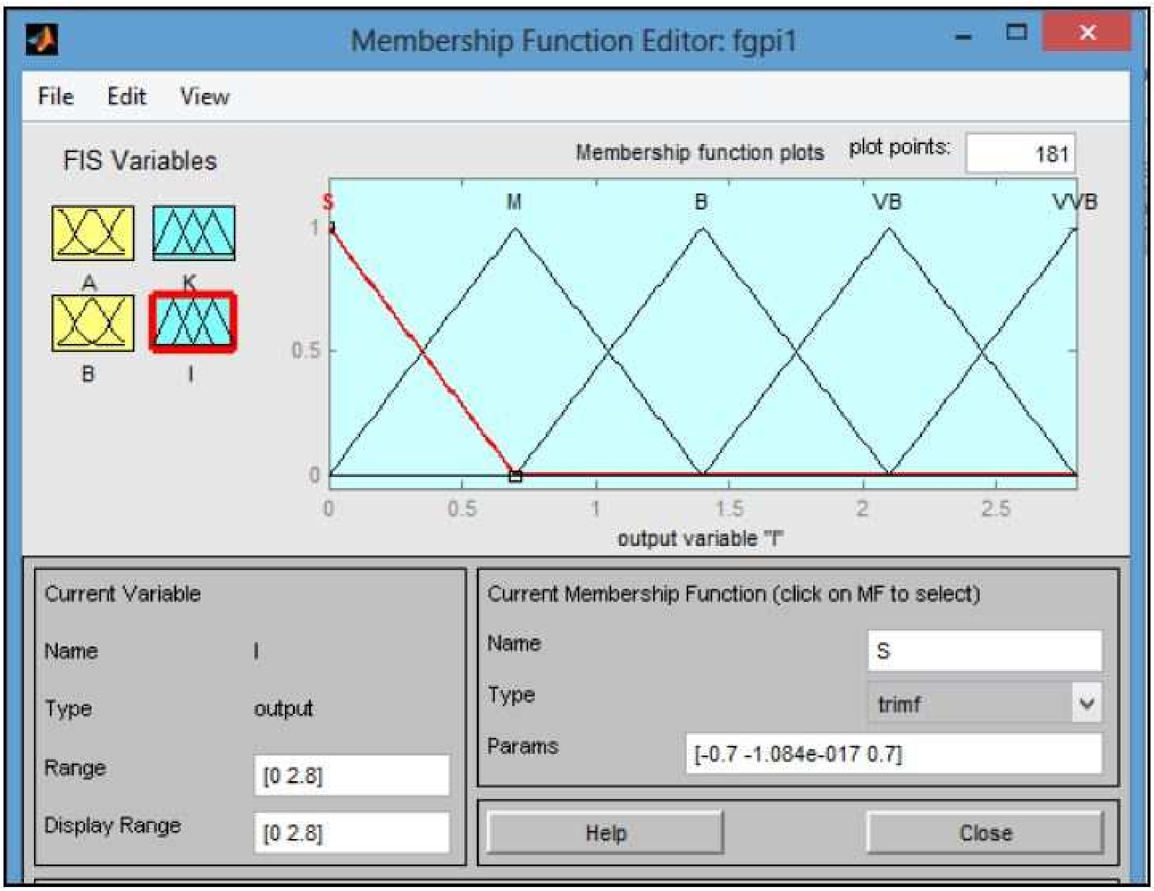

Figure 4: MMF of FIS

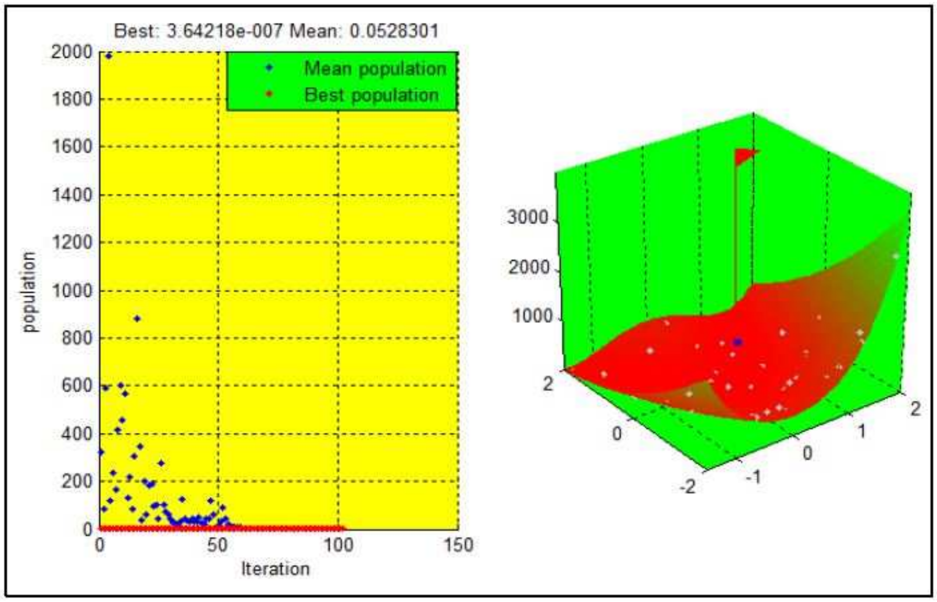

Figure 5: Random population of PSO

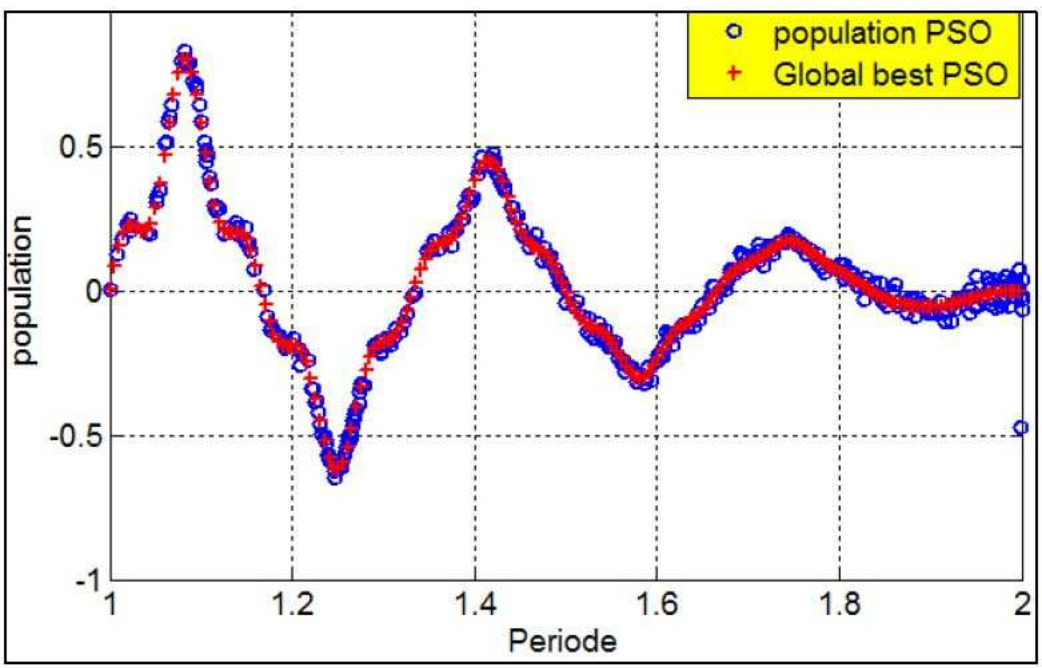

Figure 6: Global best position

compare with classical FIS method.

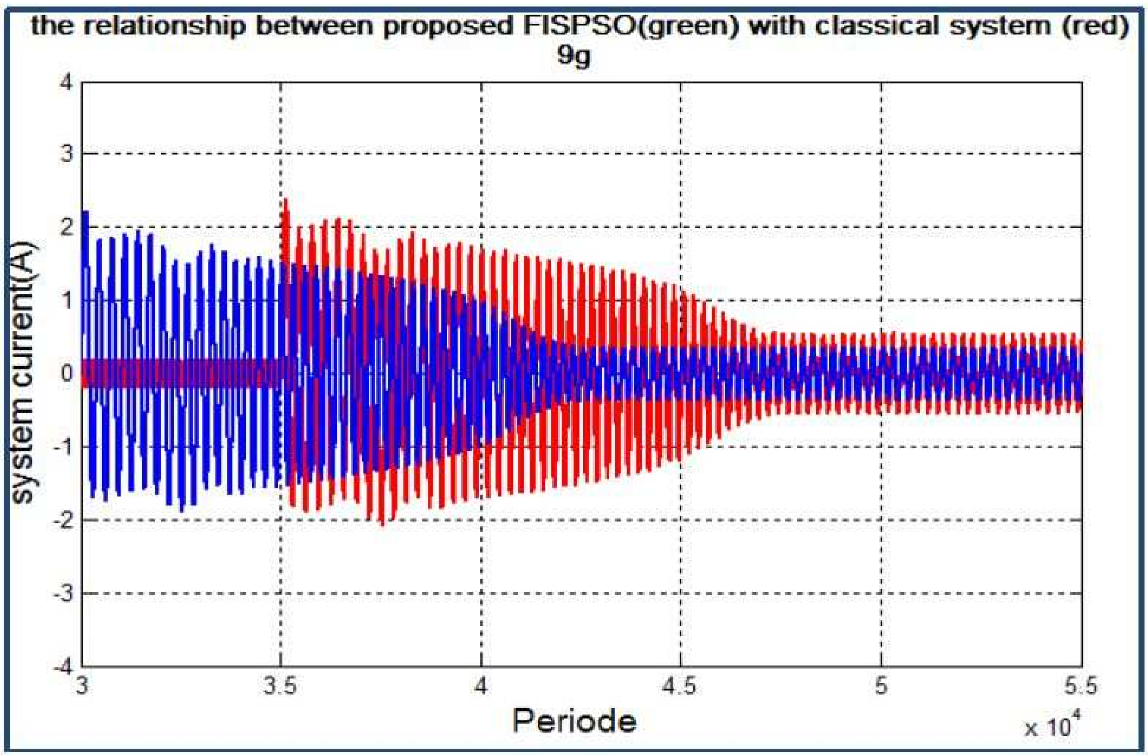

Figure 7: Current system comparison

From figure 9, it can be noted that speed of proposed system is fast response with low oscillation and high stable as compare with FIS method.

The behaviors of DC system are shown in Figure 10. Here, the response of DC system is fast response while the classical system is started in period 5000 after proposed FIS-PSO.

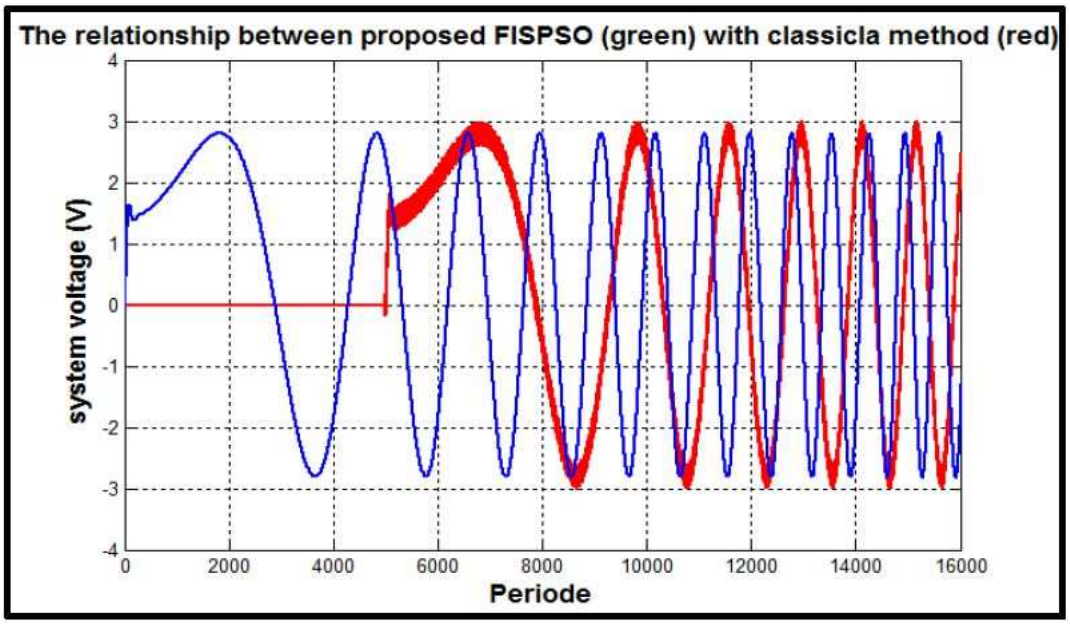

Figure 8: Voltage system comparison

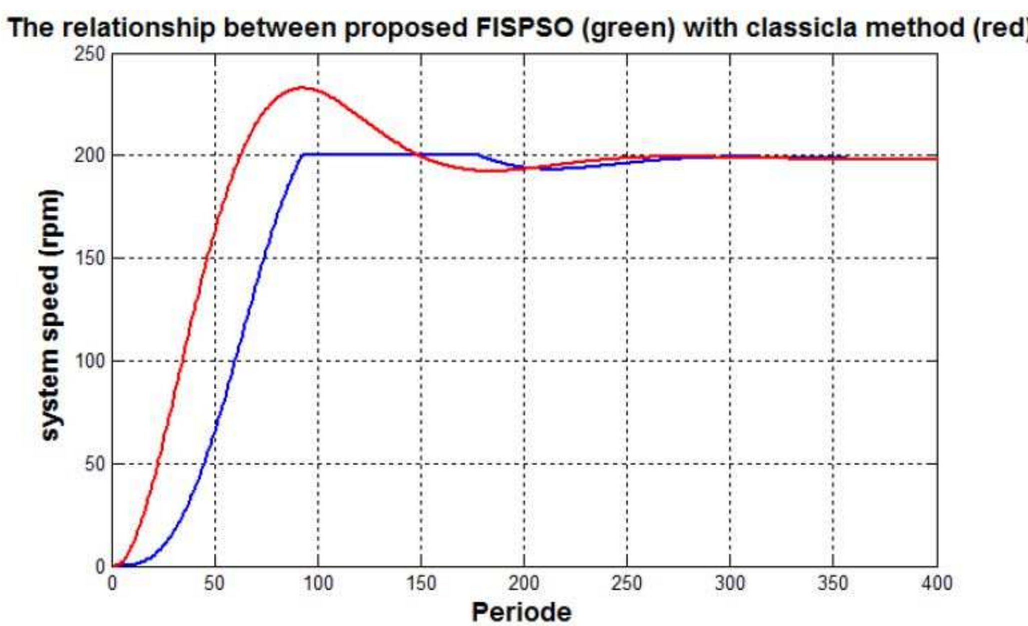

Figure 9: Speed comparison

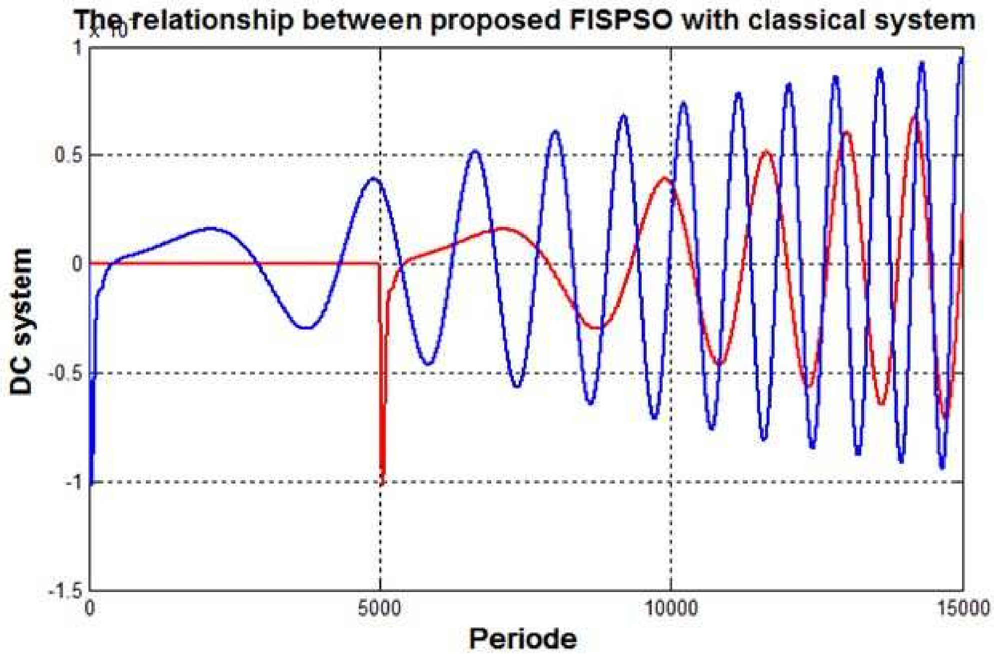

Figure 10: DC system comparison

4 Conclusion

In this study, a hybrid adaptive FIS based on particle swarm optimization (PSO) was revealed in Matlab's Simulink in order to remove the weakness of electronics system for aircraft. With this optional strategy, the accuracy of FIS is increased by PSO based on selection the best fitness function of each particle for MMF. The PSO could select the best position and velocity for particles with short calculation time. According to the realized results, the hybrid FIS-PSO is able to increase the efficiency of system in terms of high reliability and accuracy with fast response.

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