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A Novel Optimized Shunt Active Power Filter using GA and ANN in Constant Frequency Aircraft System

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Abstract

Constant instantaneous power control strategy for extracting reference currents for shunt filters have been changed with the use of Artificial Neural Network and Genetic Algorithm primarily based controller and their performances were compared. The acute evaluation of comparison of the repayment capability mostly based on THD and velocity could be carried out, and guidelines might be given for the selection of the technique for use. The simulated effects the use of MATLAB version are proven, and they will prove the importance of the proposed manipulate technique of plane shunt APF.

Keywords*: Aircraft electrical system, shunt active filter (APF), constant instantaneous power control strategy, ANN, genetic algorithm, THD*

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INTRODUCTION

The new higher craft power systems have been desired as a result of bigger utilization of electrical power, in support of additional alternate sources of energy [1–3]. The subsystems akin to flight control, customer amusement, flight surface actuators, are driven by power, which incessantly amplified the demand for building craft system more smart and superior. These subsystems have widespread more significant electrical loads, i.e., amplified supplying of power, power electronic devices, supplementary demand for power, and naturally bigger stability issues.

In idiosyncrasy to standard supply system, craft AC system mechanism uses 400 Hz source frequency [1–3]. The source voltage of 115/200 V is used in craft power utility. The loads relevant to the crafting system vary from the loads applied in 50 Hz [1]. While we premeditated the generation segment; craft power utility will stay put AC driven from the engine for the primary craft power.

When discussing about craft systems, we also have to think about enlarged power electronics use in the craft which creates harmonics, large neutral currents, waveform distortion of both supply voltage and current, poor power factor, and excessive current demand. Besides, if some non-linear loads are impressed upon a supply, their effects are additive. Due to these troubles, there may be nuisance tripping of circuit breakers or increased loss and thermal heating effects that may provoke early component failure. This is a prodigious problem to every motor load on the system. Hence, decent power quality of the generation system is of scrupulous attention to the aircraft manufacturer. We discern that aircraft systems work on high frequency; so even on the higher frequencies in the range of 360 to 900 Hz, these components would remain very significant.

Nowadays, advanced computing methods are used extensively in the automatic control, and optimization of the control system applied. A number of them are optimization of the filter (APF) using GA [4–7], fuzzy logic [8–12], power loss reduction using PSO [13], ANN [14–18] applied in collectively machinery and filter devices.

Genetic algorithm has been applied to make the performance of active filter better for the dwindling of harmonics and other delinquents created into the crafting system as a consequence of the non-linear loads [1]. The simulation outcomes noticeably show their usefulness. The simulation outcomes obtained with the novel model are a lot superior to those of usual method.

The paper has been written in the following manner: The active filter outline and the loads under contemplation are conferred in the next part of the paper. The projected control method for APF converses in the following part. MATLAB based simulation outcomes are shown, and to conclude the paper, conclusion is drawn.

SYSTEM DEPICTION

The craft system is a 400 Hz three-phase power system. As shown in Figure 1, APF gets better the power quality and recompenses the harmonic currents [19 –24]. The APF is figured out by using voltage source inverters (VSIs) fixed at the point of common coupling (PCC) to a universal DC link voltage [19, 25–27].

The craft system consists of a set of three loads. The first load (Load 1) is a 3-Φ rectifier in parallel with an inductive load and an unbalanced load connected in a phase with the midpoint (Load 1). Load 2 is a 3-Φ rectifier, which attaches a pure resistance directly. The Load 3 is a 3-Φ inductive load linked with the ground point. Lastly, a grouping of each and every load connected collectively at a dissimilar time interval to learn the efficiency of the APF. For the case of every one load connected, Load 1 is at all times connected, Load 2 is at first connected and is disconnected following every 2.5 cycles, and Load 3 is connected and disconnected after each half cycle. The simulations have been completed for 15 cycles. The circuit values are given in Appendix.

CONTROL THEORY

The projected control of APF relies upon on constant instant power control (CIPC) approach, and it is optimized victimization synthetic neural network and genetic system based controller. Constant immediately Power management approach has been referred to in brief throughout this section. The subsequent section conjointly deals with the first utility of ANN and GA based control, led inside the control schemes [28, 25, 24].

Constant Instantaneous Power Control Strategy (CIPC)

Figure 2 illustrates the control plan of the APF using CIPC technique. Four low pass filters (LPF) have been revealed in the control block; in which, three with cut off frequency of 6.4 kHz have been functional to filter the voltages, and one for the power p_0. As a result of instability quandary, direct submission of the phase voltages cannot be used in the system. There may be resonance which may occur between the passive filter and source impedance. LPFs have been used to block the voltage harmonics at the resonance frequency which is higher than 6.4 kHz. P, q, p_0, v_α, and v_β are accomplished after the estimation from α-β-0 conversion and propel to the α-β current reference block, which computes $I'_{c\alpha}$ and $i'c_\beta$. At last, α-β-0 inverse conversion block calculates the current references. Then, it will be applied to the hysteresis band controller.

Application of ANN-based Control

In this paper, constant instant power control strategy has been shaped by a synthetic neural community (ANN) created of two hidden layers with ten neurons each, and one output layer with three neurons. The power activation performance is that the bottom of the two hidden layers, neurons and linear activation carry out for the output layer neurons.

As shown in Figure 3, the ANN has seven inputs (va, vb, vc, dc voltage blunders, ia, ib, ic) and three outputs (ira, irb, irc) as discovered in the one-of-a-kind strategies. The edition of the weights (W) and bias (b) in the ANN, is primarily based, first, at the computation of the imply square errors (MSE) between the outputs of the PQ method and people of the ANN; and secondly, on the execution of 'Levenberg-Marquardt back-propagation' algorithm.

The reference present day generation unit and dc voltage controller unit has been shapely, and their individual and co-happening effect were found.

Application of Genetic Algorithm

GA is a search method used in calculation to discover a best possible solution for a search issue [4]. It is realized as a simulation in which chromosomes of the genome of individuals to an optimization problem advance towards superior solutions [6]. Usually, the fittest individuals of any population are susceptible to replicate and endure to the next generation, thus bettering the consecutive generations [7].

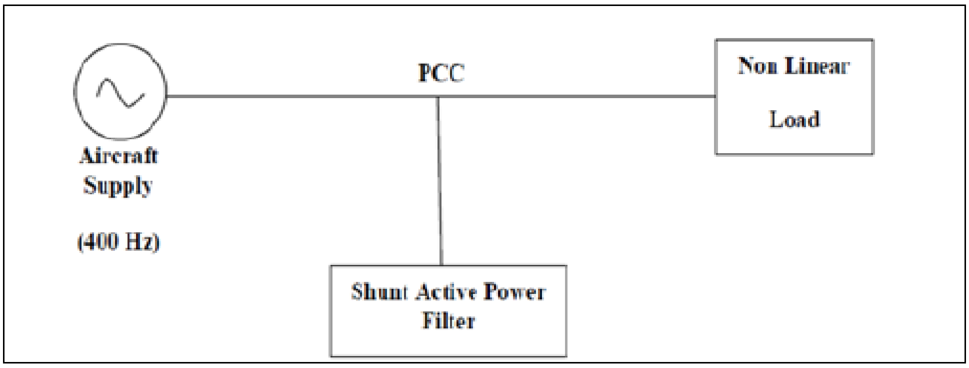

Fig. 1: *Craft System Using APF.*

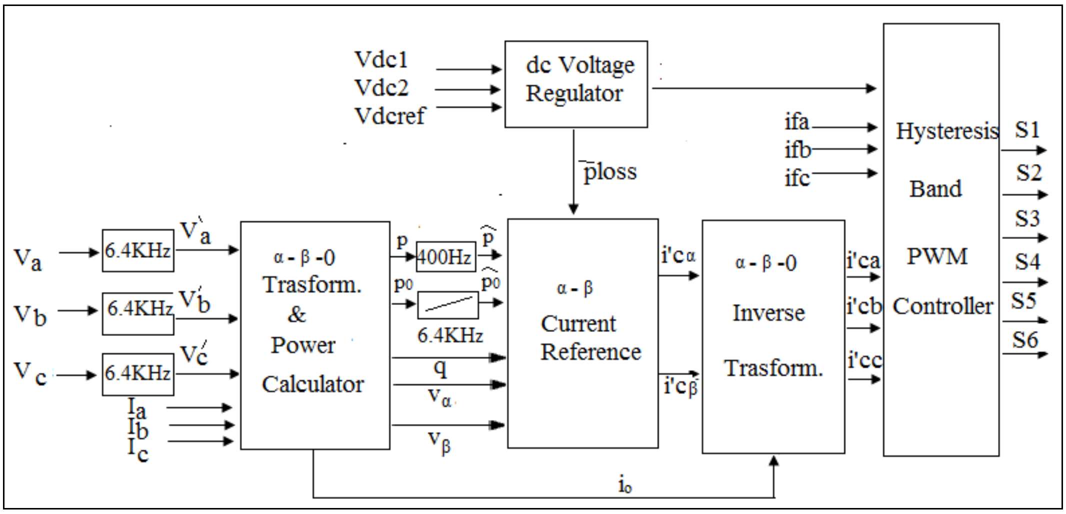

Fig. 2: *Control Block Diagram of the Shunt Active Filter Using Constant Instantaneous Power Control Strategy.*

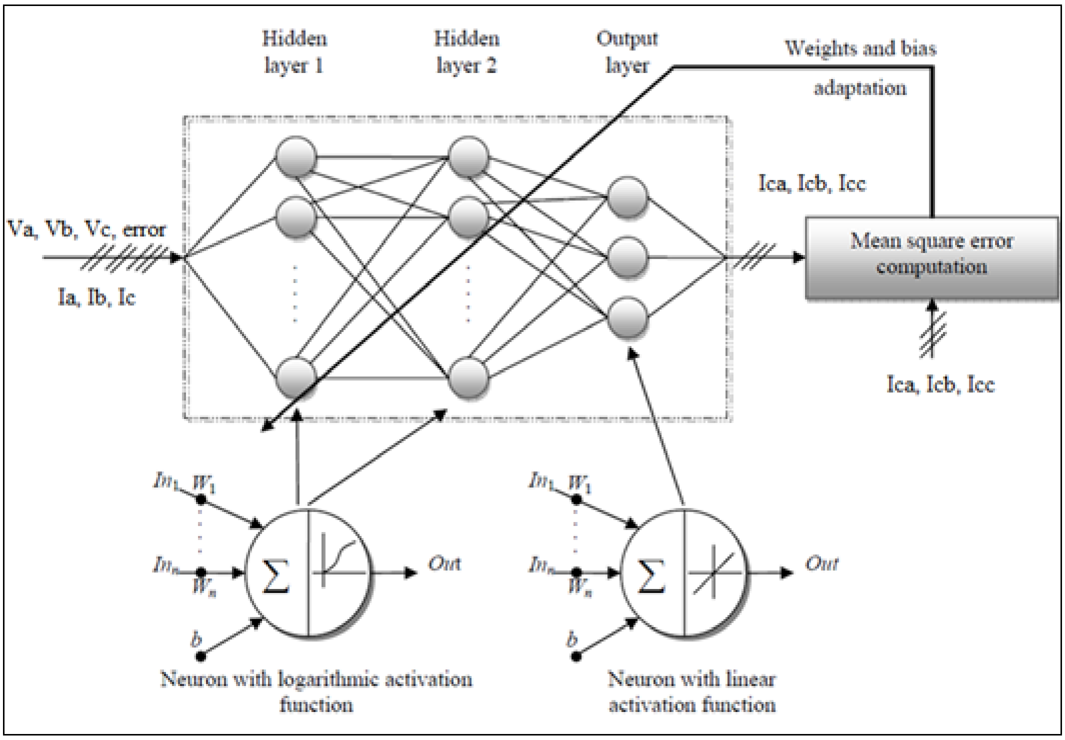

Fig. 3: *Artificial Neural Network for Modeling.*

Usually, the algorithm ends while either the most number of generations have been created, or an acceptable fitness level has been attained for the population [7]. The fitness function is characterized by the genetic illustration and assesses the class of the signified solution. The fitness function is at all times problem reliant [6]. By starting at some independent points and seeking in parallel, the algorithm stays away from local minima and evades assembling to suboptimal results. In this fashion, GA has been publicized to be competent of spotting good performance areas in intricate domains devoid of experiencing the issues linked with high dimensionality [15].

Many researchers have established that using genetic algorithm optimization tool (GAOT). MATLAB gives numerous included auxiliary functions helpful for function optimization [15–29]. GAOT is not only easy to put into practice but is faster in simulating.

GA is applied to find out the best value of inductor filter (L_f). Supply side has been considered as input for L_f. L_f value used is 0.25 mH. Offline, simulation using Simulink has been applied to detect the finest value for L_f.

The limits, inequality and bounds must be defined. This paper has endeavored to evolve a program for ameliorating objective function.

x0=[V_{dc}; V_s; I_c; t; L_f];

lb=[V_{dcmin}; V_{smin}; I_{cmin}; t_{min}; L_{fmin}];

ub=[V_{dcmax}; V_{smax}; I_{cmax}; t_{max}; L_{fmax}];

Aeq=[];

beq=[];

A=[1 –1 1 –1 1; 1 1 –1 1 –1; 0 0 1 1 1; 1 1 –0 0 –1; 1 1 0 1 0];

b=[Values of V_{dc}; V_s; I_c; t; L_f depending upon the equations];

[x, fval, exitflag]=fmincon(@myobj, x0, A, b, Aeq, beq, lb, ub)

The limits and boundary in the APF have been determined using the data available of previous simulated ANN model. The simulation data has been fetched using Simulink. At last, a program using GA has been created to produce the optimum value of the L_f. Subsequent to the computation; GA creates the value of 0.187 mH. THD for voltage and current have been lessened using this L_f value. Thus we can declare that L_f value calculated is finest.

SIMULATION RESULTS AND DISCUSSIONS

APF is simulated in Simulink to ensure its performance. An inductor (small value) is also attached to the terminals of the load to acquire the adequate compensation. THD of current and voltage has been reduced significantly which proves the technique efficiency.

Uncompensated System

The current and voltage waveforms for uncompensated craft system have been shown in Figure 4.

It has been examined that the THD of source current is 9.5% and THD of source voltage is 1.55%. By reviewing these THDs, one can simply deduce that supply side has been polluted when loads have been attached. This data shows that THDs are not within the boundary of the international standard.

Compensated System

The performance of APF under entirely distinct loads related, once using ANN control has been referred to underneath for the manipulate method given underneath:

For Constant Instantaneous Power Control Strategy

From Figure 5 it has been empiric that the THDs of source current and source voltages were 3.01 and 1.88% respectively.

At t=0.0147 sec, i.e., compensation time, it is noticeable that the w/f for voltage and current have become sinusoidal. Figure 5 illustrates the waveforms of the compensated system.

The irregularity in dc voltage is highly visible in the waveforms. The compensation current for completing the demand of load current releases the energy. After that, it tries to get its set value.

For Constant Instantaneous Power Control Strategy using ANN and GA

THDs of supply current and voltage are located 2.72 and 1.07% severally once creating observations from the simulation results shown in Figure 6. The waveforms for supply voltage and supply present day have become sinusoidal at t=0.0064 sec. Compensation time is 0.0064 sec. The waveforms of reimbursement cutting-edge, dc electric condenser voltage, and load modern-day are proven in Figure 6. Waveforms show the versions in dc electric condenser voltage. Whenever the call for top load modern comes, it releases the power that successively will grow the present repayment day; later on, its prices and attempts to regain its previous set price. By growing a truthful observation, we are capable of mentioning that reimbursement contemporary is gratifying the demand of load present day. Once the energetic filtering is done, the supply current and voltage is forced to be sinusoidal curving.

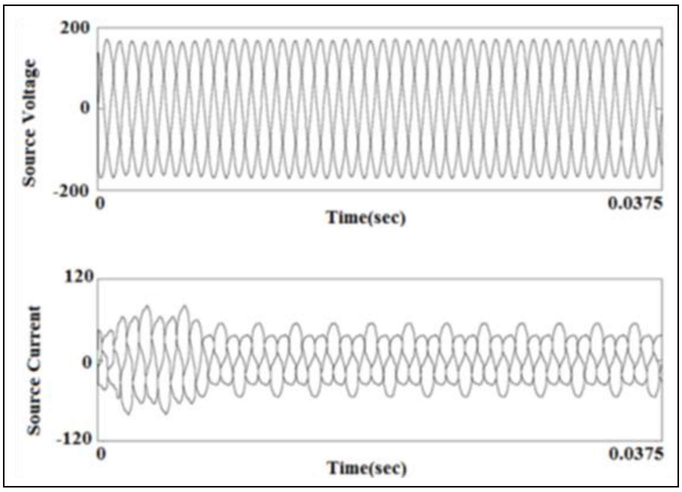

Fig. 4: *Waveforms of an Uncompensated System (Source Voltage and Source Current).*

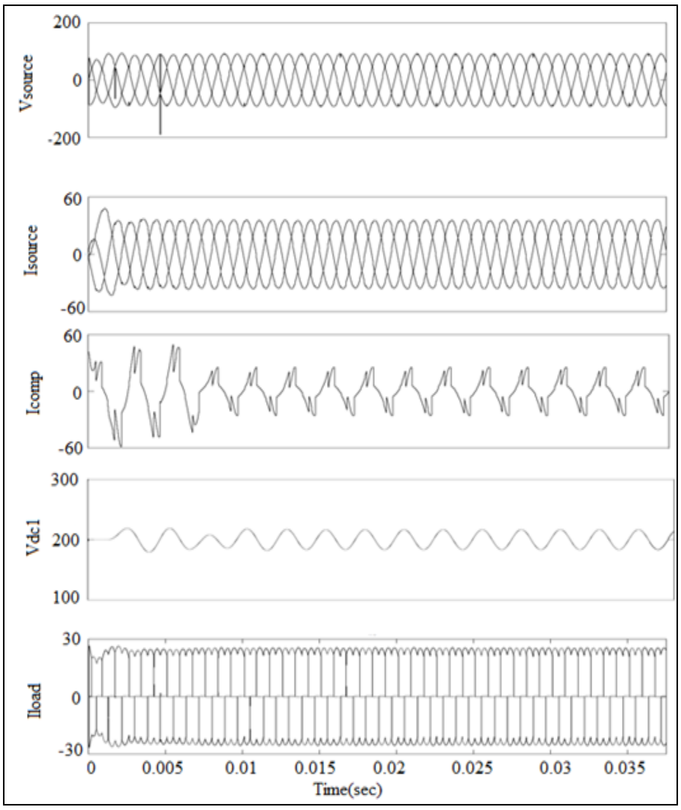

Fig. 5: *Source Voltage, Source Current, Compensation Current (Phase B), DC Link Voltage and Load Current Waveforms of Active Power Filter Using Constant Instantaneous Power Control Strategy.*

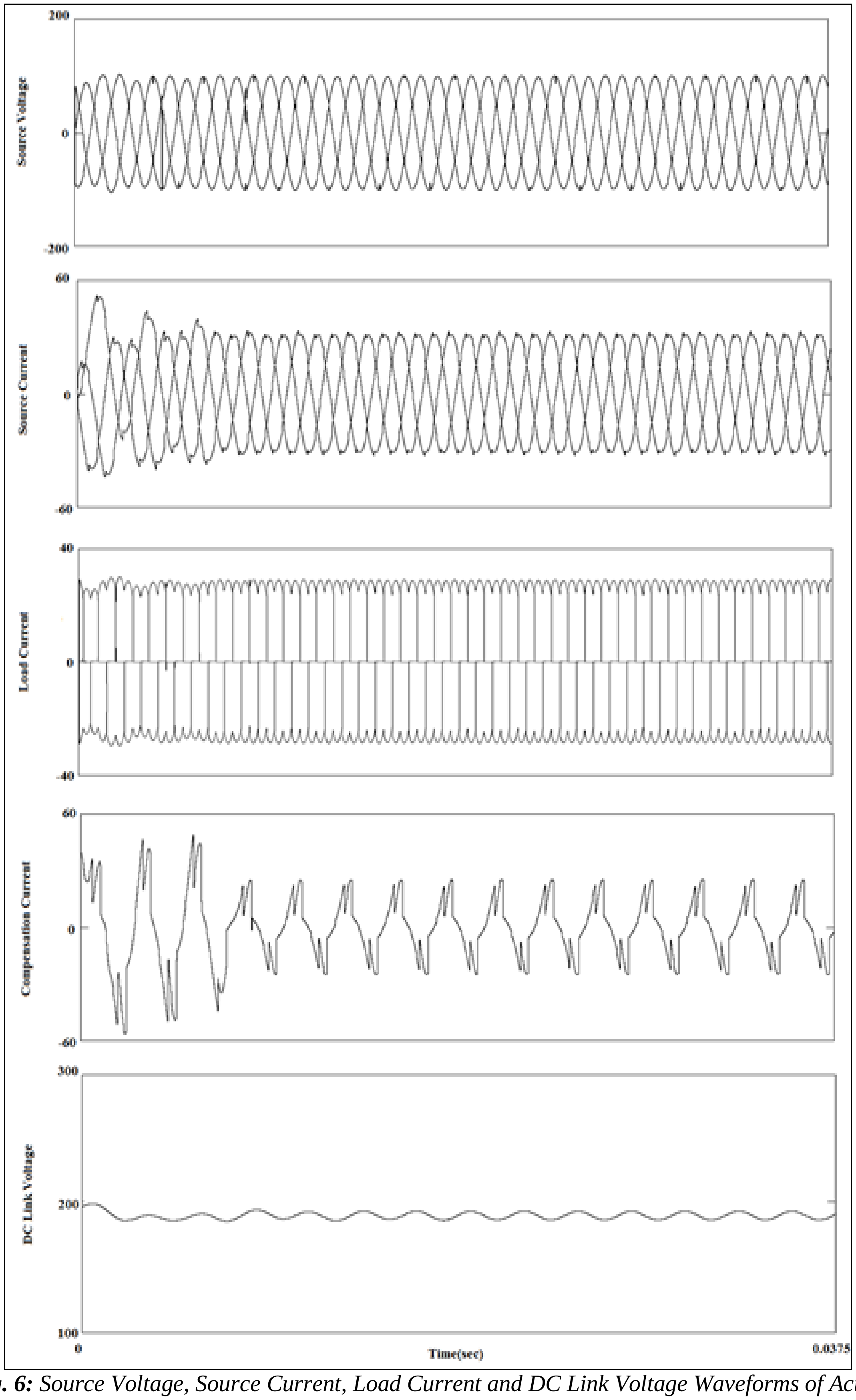

Fig. 6: *Source Voltage, Source Current, Load Current and DC Link Voltage Waveforms of Active Power Filter using Constant Instantaneous Power Control Strategy using ANN and Genetic Algorithm with All Three Loads Connected to Aircraft System.*

Comparative Analysis of the Simulation Results

From the Table 1, we can merely say that constant instant power control strategy victimization ANN and genetic algorithmic program along (CIPC-ANN-GA) has been found best for current and voltage harmonic reduction. Once these results are compared, supported compensation time, it has been additionally found that CIPC-ANN-GA strategy is also quickest one.

Table 1: *Summary of Simulation Results.*

Strategy	THD-I (%)	THD-V (%)	Compensation Time (sec)
CIPC	3.01	1.88	0.0147
CIPC-ANN-FUZZY	2.72	1.07	0.0065

CONCLUSION

This paper has executed an acute evaluation of conventional, ANN and Genetic Algorithm carried out together for shunt APF in aircraft electricity software of 400 Hz. Optimum selection of manipulate strategy based totally on compensation time, and THD has been recommended. Overall constant instantaneous power control strategy using ANN and Genetic Algorithm together (CIPC-ANN-GA) has been located as the best preference. Constant instantaneous power control strategy's overall performance has been improved; which itself and fulfillment for the case of optimization in traditional techniques.

APPENDIX

The aircraft system parameters are [1]:
Three-phase source voltage: 115 V/400 Hz
Filter capacitor: 5 µF,
Filter inductor=0.25 mH
Dc capacitor: 4700 µF
Dc voltage reference: 400 V

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