STM JOURNALS
Journal of Aerospace Engineering & Technology
ISSN: 2231-038X (Online), ISSN: 2348-7887 (Print)
Volume 8, Issue 1
www.stmjournals.com

# Genetic Algorithm Application in Shunt Active Power Filter Applied in Constant Frequency Aircraft System

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***Abstract***
*In the present paper, Constant Instantaneous Power Control (CIPC) technique for extracting reference currents for shunt active power filters has been optimized using genetic algorithm, and its performances have been compared. The delicate analysis of assessment of the compensation ability based on THD and compensation time has been done, and recommendations are presented for the preference of technique to be used. The simulated results using Simulink model are shown, and they will indubitably demonstrate the significance of the proposed control technique of craft APF.*

***Keywords**: Aircraft electrical system, shunt active filter (APF), constant instantaneous power control strategy, harmonic compensation, GA, total harmonic distortion*

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## INTRODUCTION

The new superior 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 etc. are driven by power, which incessantly amplify the demand for building the craft systems more smart and superior. These subsystems have widespread bigger 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 craft 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 craft primary 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 instinctive control, and optimization of the control system applied. A number of them are: optimization of the filter (APF) by means of GA [4–7], fuzzy logic [8–12], power loss reduction using PSO [13], and ANN applied collectively in machinery and filter devices [14–18].

Genetic algorithm has been applied to make the performance of active filter better for the dwindling of harmonics and other delinquents created into the craft 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 afterwards. MATLAB based simulation outcomes and the conclusion are presented in the following part of the paper.

**System Depiction**

The craft system is a 400 Hz three-phase power system. As for showing 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 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 each and 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, 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.

## PROPOSED SCHEME

The proposed control of APF relies upon CIPC technique, and it has been optimized using GA. CIPC strategy has been conferred in short. The subsequent section also deals with the prime application of GA in the technique [19, 20, 24–26, 29].

**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 are higher than 6.4 kHz. P, q, $p_0$, $v_\alpha$ and $v_\beta$ 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 GA to the APF**

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]. Normally, the fittest individuals of any population are susceptible to replicate and endure to the next generation, thus bettering the consecutive generations [7]. Usually, the algorithm ends while either the most number of generations has been created, or an acceptable fitness level has been attained for the population [7]. The fitness function is characterized over the genetic illustration and assesses the class of the signified solution. The fitness function is at all times problem reliant [6]. By starting at a number of 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 using genetic algorithm optimization tool (GAOT). MATLAB gives numerous included auxiliary functions helpful for function optimization [15]. 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 $L_f$.

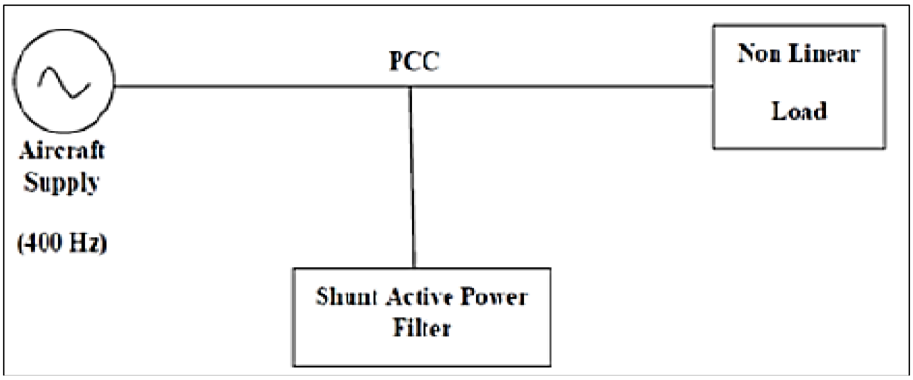


***Fig. 1:** Craft System Using APF.*

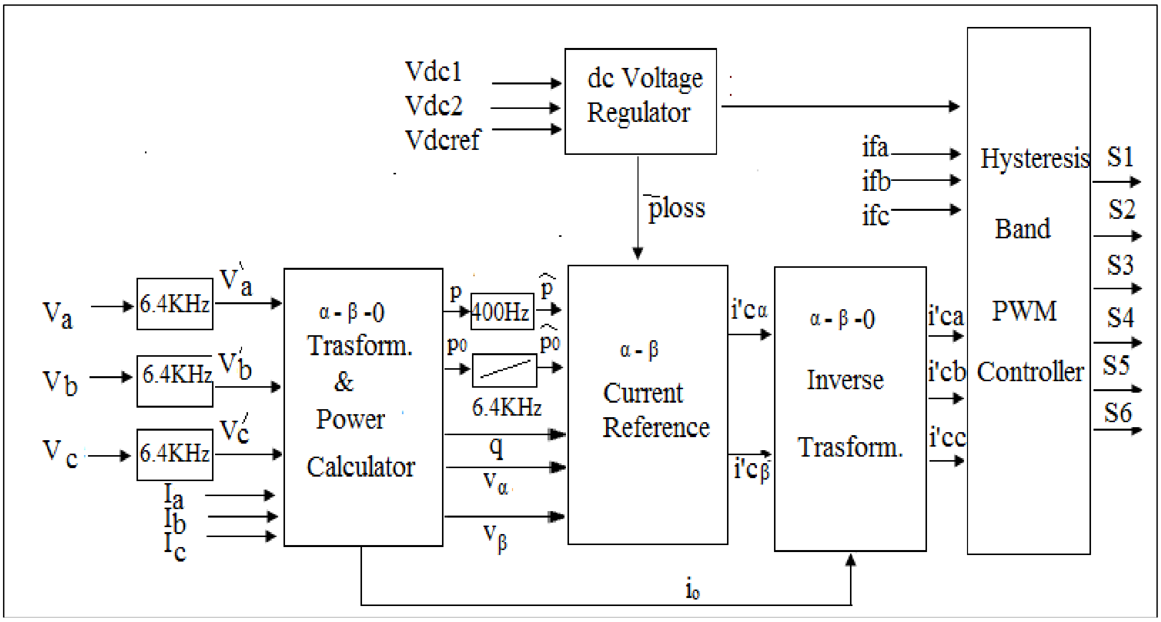


***Fig. 2:** Control Block Figure of the APF Using CIPC Technique.*

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.

## 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 effective 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 3.

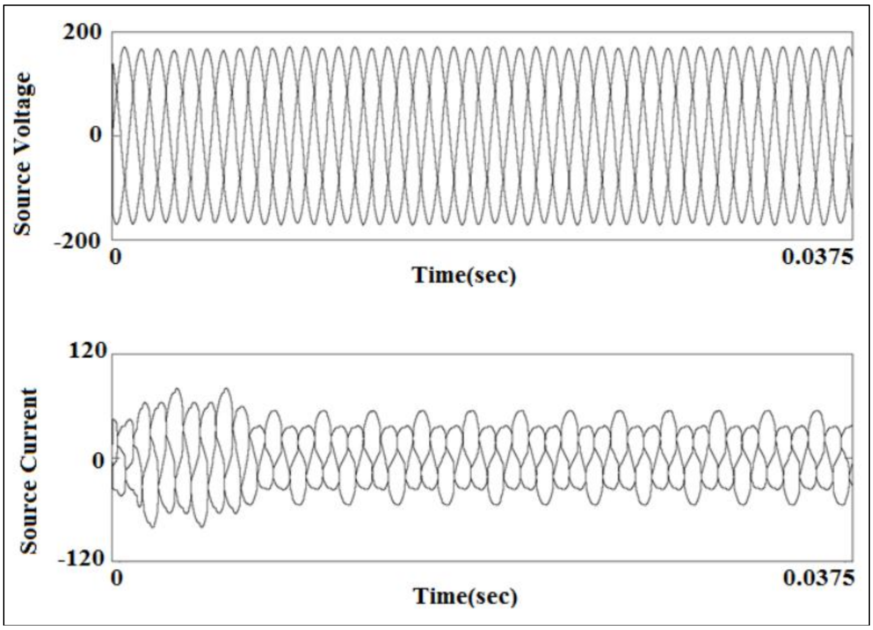


***Fig. 3:*** *Waveforms of Uncompensated System (Source Voltage and Source Current).*

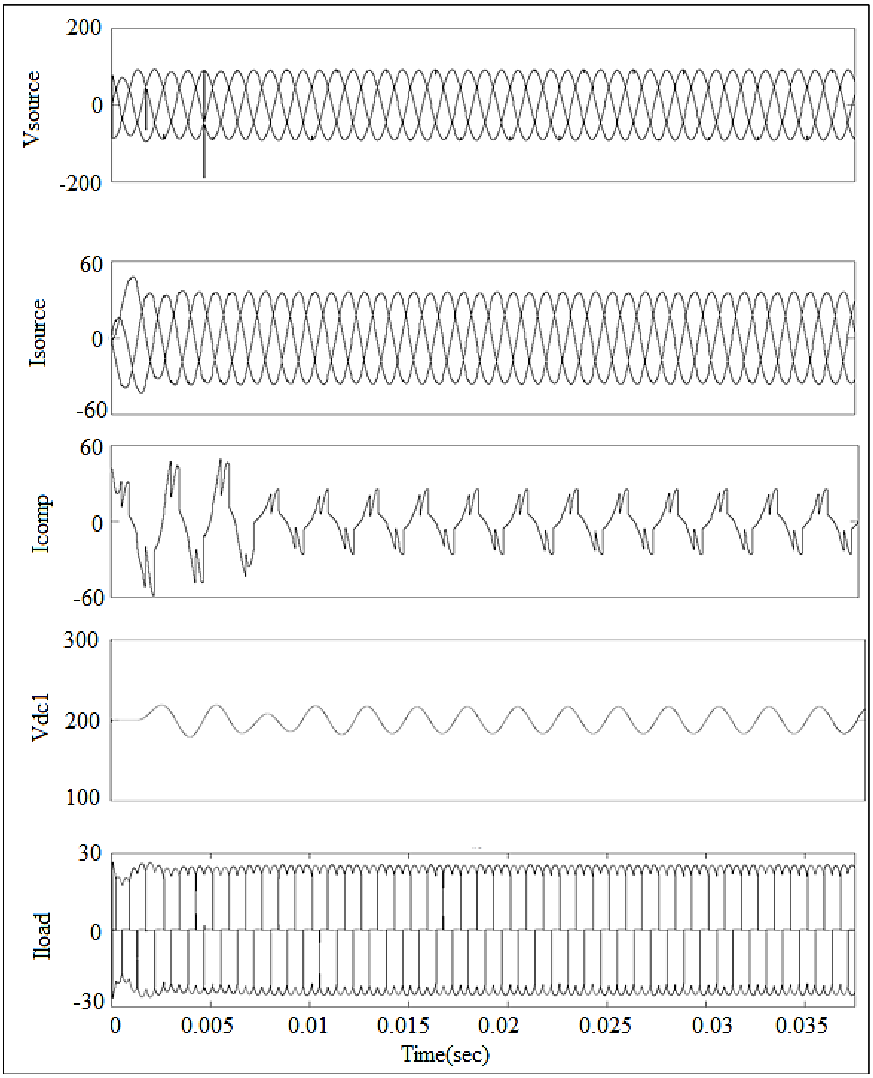


***Fig. 4:*** *Waveforms of APF Using CIPC Strategy.*

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

**Compensated System**

When GA has been used, the performance of APF under different loads attached has been talked about below.

***For CIPC***

From Figure 4, it has been empiric that the THDs of source current and source voltage 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 4 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. Thereafter, it tries to get its set value.

***For CIPC Technique Using GA***

From Figure 5, it has been empiric that the THDs of source current and source voltage were 2.12 and 1.88% respectively.

At t=0.0066 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.

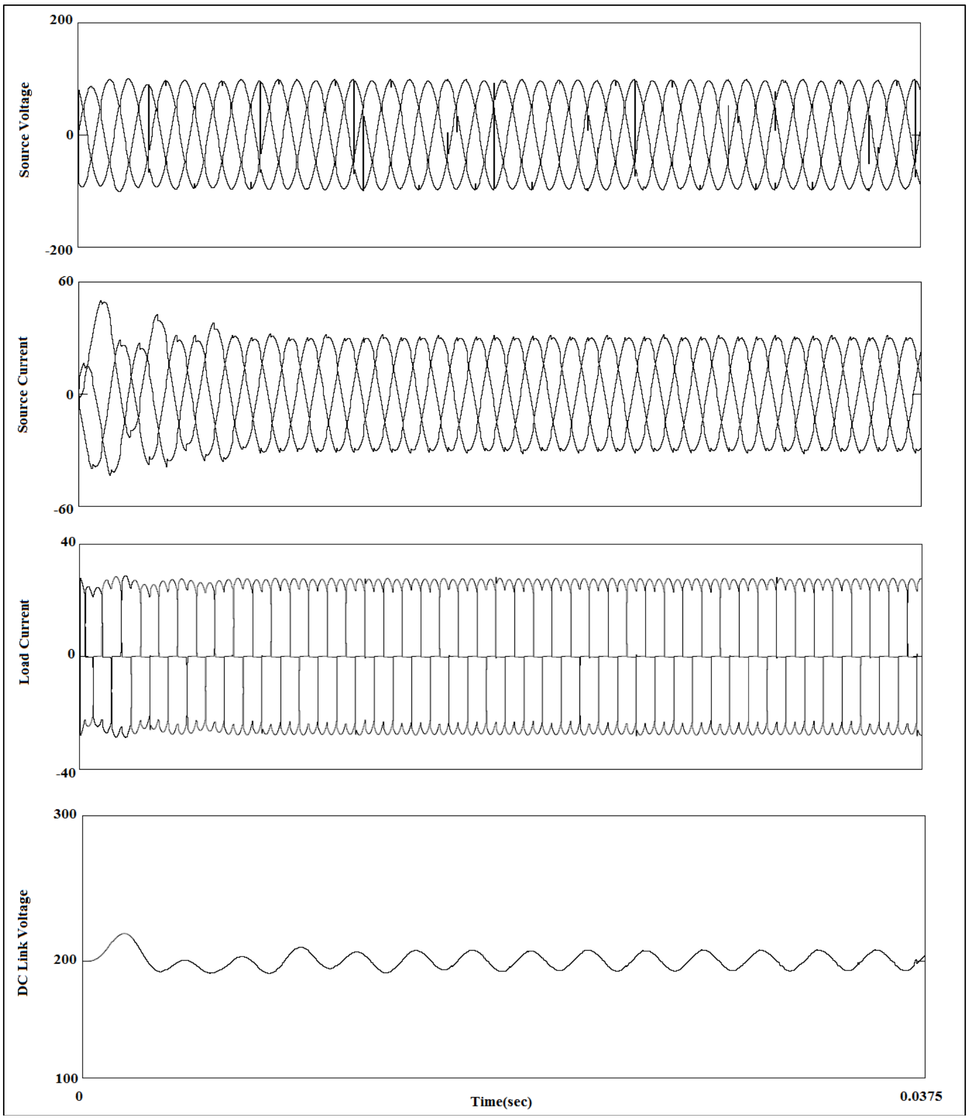


***Fig. 5:*** *Waveforms of APF using CIPC-GA.*

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

**Comparative Investigation of the Simulation Results**

From the Table 1, we can effortlessly declare that CIPC technique using GA (CIPC-GA) has been established best for voltage and current harmonic reduction. The compensation time comparison among the techniques also proves the same.

***Table 1:*** *Summary of Simulation Results.*

| Strategy | THD-I (%) | THD-V (%) | Compensation Time (sec) |
|---|---|---|---|
| CIPC | 3.01 | 1.88 | 0.0147 |
| CIPC-GA | 2.12 | 1.88 | 0.0066 |

## CONCLUSION

This paper has done a delicate investigation of established CIPC and CIPC-GA for APF in craft power utility of 400 Hz. The finest selection of control technique based on compensation time and THD has been recommended. On the whole, CIPC-GA has been detected as an optimum choice. CIPC's performance has been advanced, which itself is an accomplishment for the case of optimization in traditional strategies.

**Appendix**

The craft 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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**Cite this Article**

Saifullah Khalid. Genetic Algorithm Application in Shunt Active Power Filter Applied in Constant Frequency Aircraft System. *Journal of Aerospace Engineering & Technology*. 2018; 8(1): 44–50p.