SIMULATION OF SHUNT ACTIVE FILTERS BASED ON SINUSOIDAL CURRENT CONTROL STRATEGY IN HIGH FREQUENCY AIRCRAFT SYSTEM

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Abstract

Sinusoidal Current Control Strategyfor extracting reference currents for active filters have been evaluated and its performance has been discussed under various non linear loads. Evaluation of compensation ability of control strategy based on THD and speed will be done under different loads. Simulation results using MATLAB have been included.

Index Terms— Active power filter (APF), Sinusoidal Current Control Strategy, harmonic compensation, aircraft power utility.

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I. INTRODUCTION

Need of improved aircraft power systems [1]-[3] have been increased significantly due to unavailability of other alternate power sources except than electrical power source

New advanced concepts based aircraft uses electric power to drive its subsystem such as flight surface actuators, flight control, passenger entertainment, etc. These new additive subsystems has significantly increased electrical loads i.e. power electronic devices, more consumption of electrical energy, great demand for generated power, and much more power quality and stability problems.

Aircraft ac power system uses three phase system of source frequecny of 400 Hz [1]-[3]. Due to the increased power electronics application in aircraft, unbalances and the harmonics creates more losses and bad power supply performances. These harmonics may interfere with communication circuits and change the response of the sensitive equipment in such a bad manner that the power supply quality will degrade and the generation system may be polluted. By the application of shunt active power filters in aircraft can eliminate harmonic, reactive and unbalanced currents, improve the power supply performance and the stability of system.

Now a days, the intelligent algorithms are used widely in control system or for optimization of the system applied. Some of them are such as adaptive tabu search [4]-[8] used for finding the optimized values of the controllers variables[4]-[12], optimization of active power filter using GA[9]-[12], power loss minimization using particle swarm optimization[13], neural network control [14]-[18].

This paper presents simulation of Sinusoidal Current Control Strategy for the extraction of the reference currents for a shunt active power filter connected to aircraft power utility. Block diagram of the system using control strategy has been shown in Figure 1. Circuit has been simulated using MATLAB/Simulink and their evaluation has been done under various loads connected alone and together [1].

The organization of the paper has been done in the following manner. The control strategy has been discussed in Section II. Comparative evaluation of their performance using MATLAB/ Simulink results has been discussed in Section III and finally Section IV concludes the paper.

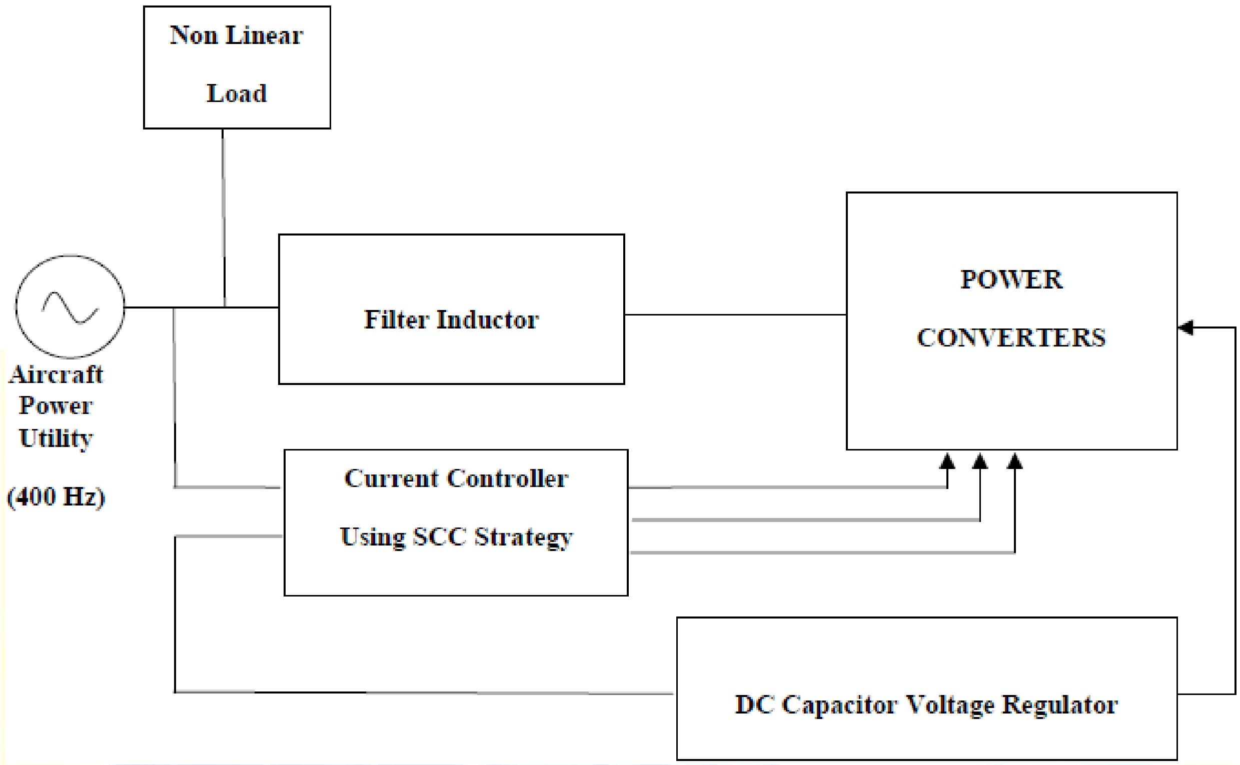

Figure 1 Block diagram of the system using Sinusoidal Current Control Strategy

II. SINUSOIDAL CURRENT CONTROL STRATEGY (S.C.C.)

Sinusoidal current control strategy is a modified version of constant source instantaneous power strategy, which can compensate load currents under unbalanced conditions too. So initially we shall discuss about constant source instantaneous power strategy. Figure 2 presents the control diagram of the shunt active filter using constant source instantaneous power strategy We can observed that four low pass filters have been shown in the control block; in which, three with cut off of 6.4 KHz has been applied to filter the voltages and one for the power p_0. Direct application of the phase voltages cannot be used in the control due to instability problem. There may be resonance between source impedance and the small passive filter. Low pass filters have been applied to the system to attenuate the voltage harmonics at the resonance frequency which are higher than 6.4 KHz. p, q ,p_0 ,$v_\alpha$and v_β are obtained after the calculation from α-β-0 transformation and send to the α-β current reference block, which calculates $i'_{c\alpha}$ and $i'_{c\beta}$. Finally, α-β-0 inverse transformation block calculates the current references and applied to the PWM current control i.e. hysteresis band controller.

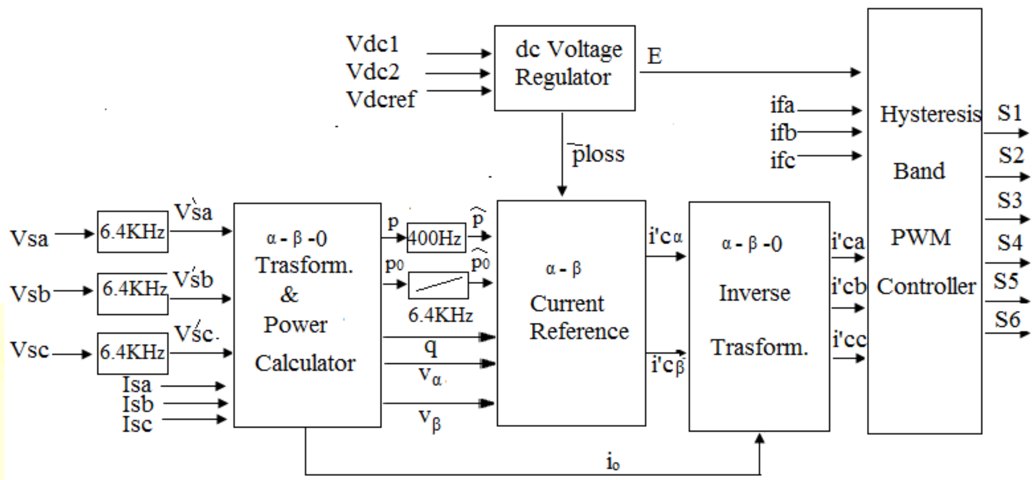

Figure 2 Control block diagram of the shunt active filter using constant source instantaneous power strategy

The modification includes a positive sequence detector which replaced the 6.4 KHz cutoff frequency low-pass filters and correctly finds the phase angle and frequency of the fundamental positive sequence voltage component and thus shunt active power filter compensates the reactive power of the load. While designing this detector, utmost care should be taken so that shunt active filter produces ac currents orthogonal to the voltage component, otherwise it will produce active power. i_α, i_β , p' and q'are obtained after the calculation from α-β-0 transformation block and send to the α-β voltage reference block, which calculates $v_{\alpha'}$ and $v_{\beta'}$. Finally, α-β-0 inverse transformation block calculates the V'sa, V'sb and V'sc. In place of the filtered voltages used previously, V'sa, V'sb and V'sc are considered as input to the main control circuit of figure 2. Now fundamental negative sequence power, harmonic power, and the fundamental reactive power, are also included in the compensating powers.

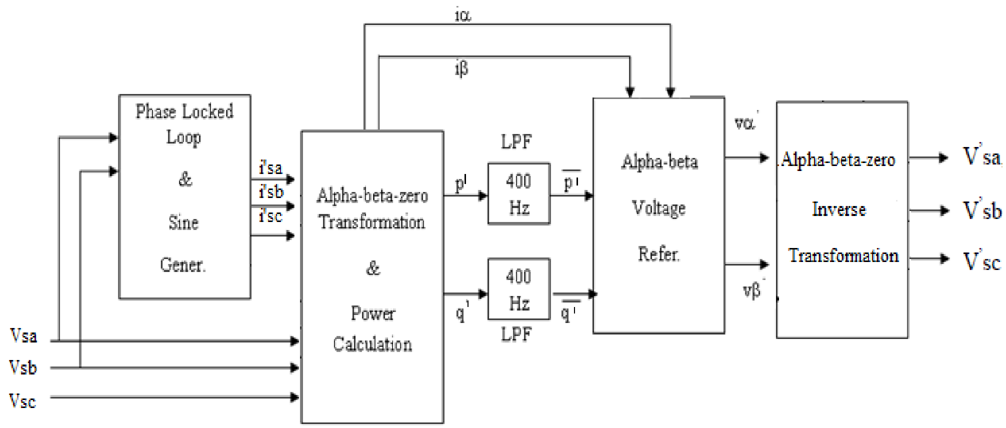

Figure 3 Block diagram of the fundamental positive-sequence voltage detector for sinusoidal current control strategy

III. EVALUATION USING SIMULATION RESULTS

Sinusoidal current control strategy has been simulated using MATLAB/Simulink to evaluate their performance. Three loads has been used i.e. three-phase rectifier parallel with inductive load and an unbalanced load connected a phase with midpoint, the three-phase rectifier connects a pure resistance directly, three-phase inductive load linked with the ground point and combined all three loads connected with system together at different time interval.

The simulation results undoubtedly exhibit that active filter is capable to effectively reduce the significant amount of THD in source current and voltage within limits. Simulation has been done for 15 cycles and results have been analyzed on the basis of THD and response time obtained.

A. Performance of APF under load 1(three-phase rectifier parallel with inductive load and an unbalanced load connected a phase with midpoint)

From the simulation results shown in figure 4, it has been observed that that the THD of source current & source voltage was 2.43% and 1.44% respectively. The response time for compensation was 0.0074 sec.

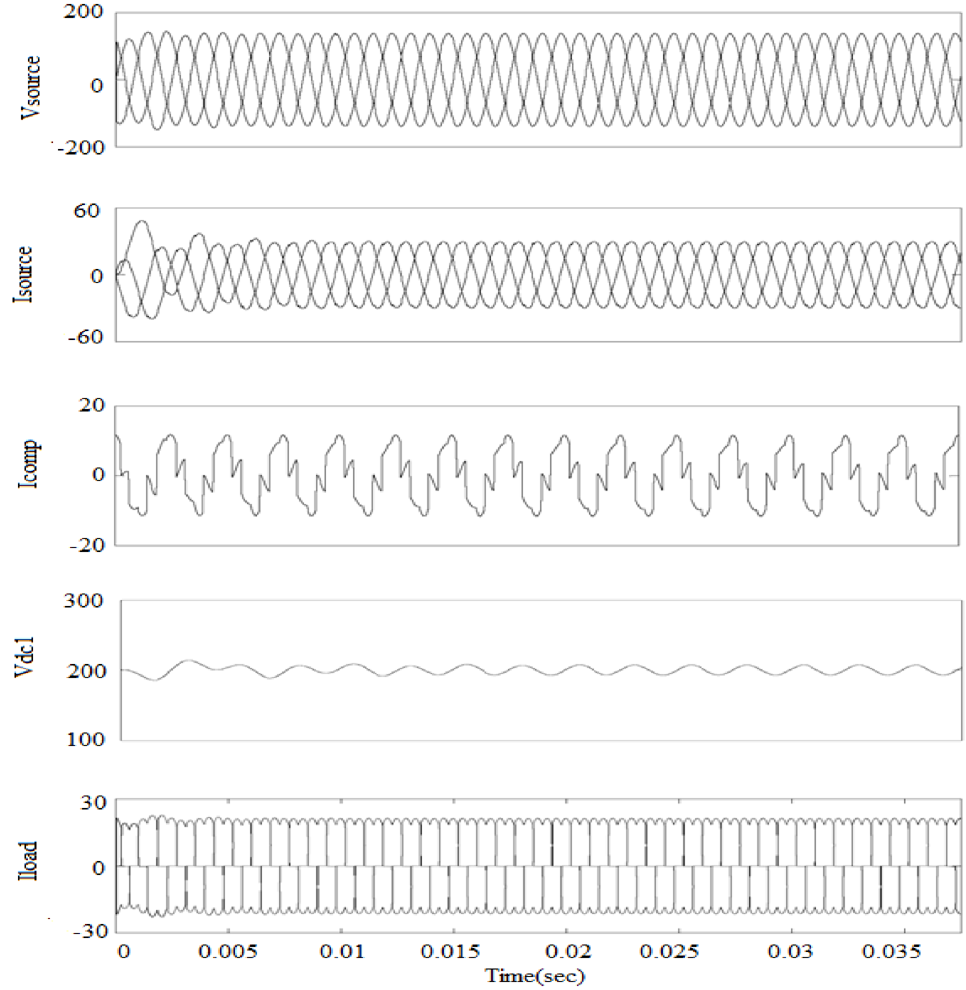

Figure 4 Source Voltage, source current, compensation current (phase b), DC link Voltage and load current waveforms of Active power filter using sinusoidal current control strategy with three-phase symmetrical nonlinear load condition for aircraft power utility

B. Performance of APF under load 2(three-phase rectifier connected a pure resistance directly)

From the simulation results shown in figure 5, it has been observed that that the THD of source current & source voltage was 2.30% and 1.29% respectively. The response time for compensation was 0.0085 sec.

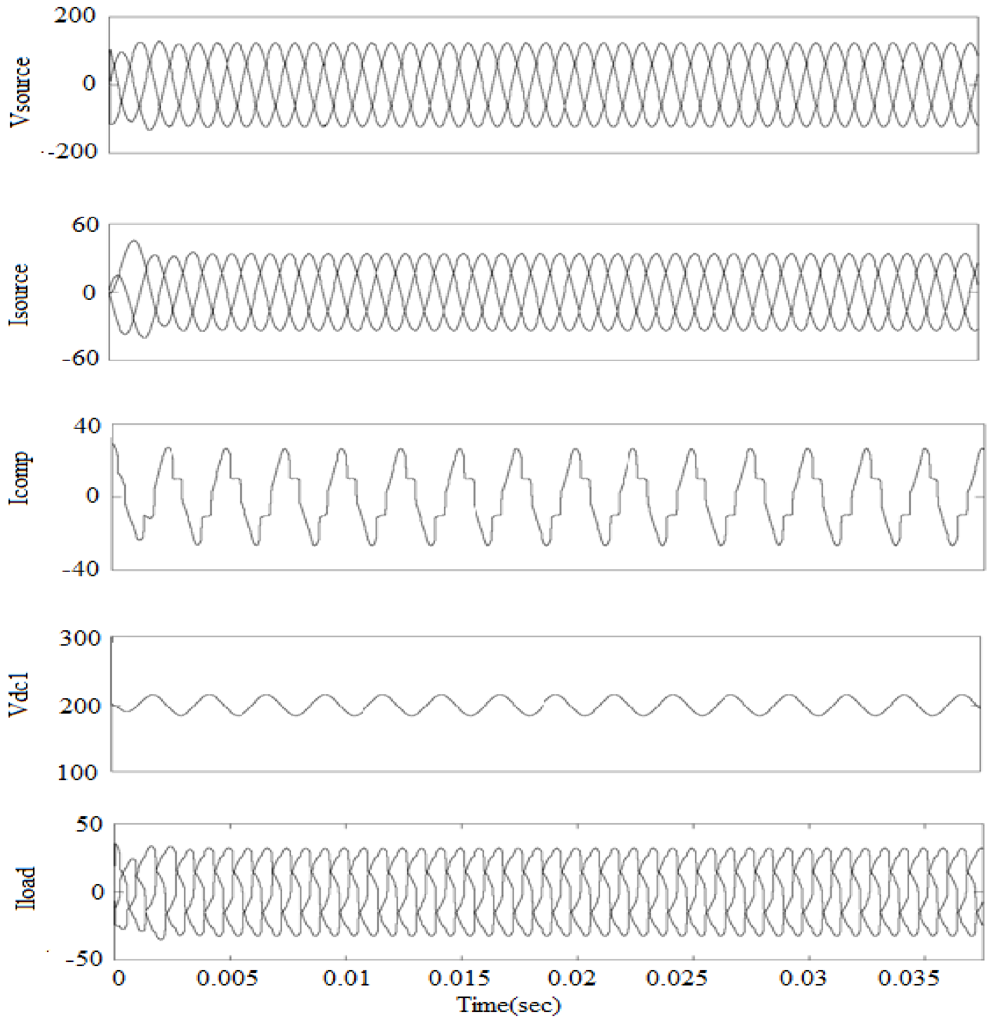

Figure 5 Source Voltage, source current, compensation current (phase b), DC link Voltage and load current waveforms of Active power filter using sinusoidal current control strategy with three-phase symmetrical nonlinear and inductive load condition for aircraft power utility

C. Performance of APF under load 3(three-phase inductive load linked with the ground point)

From the simulation results shown in figure 6, it has been observed that that the THD of source current & source voltage was 0.44% and 0.32% respectively. The response time for compensation was 0.0074 sec.

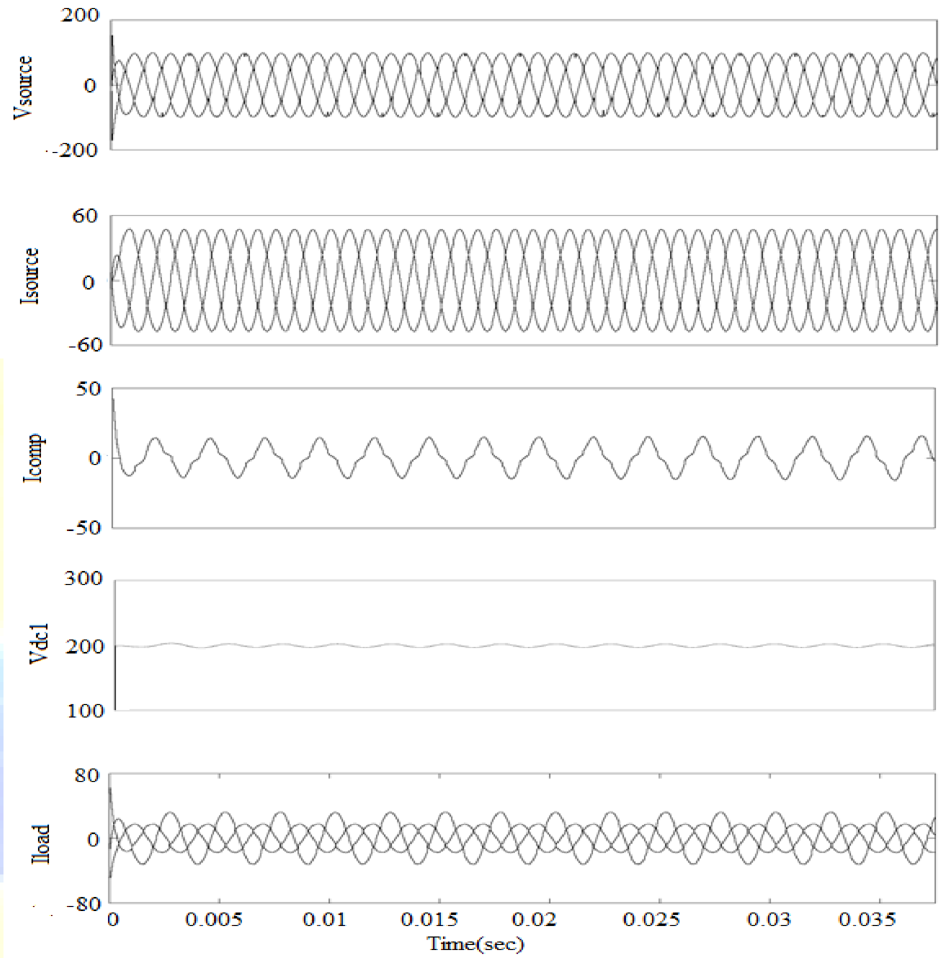

Figure 6 Source Voltage, source current, compensation current (phase b), DC link Voltage and load current waveforms of Active power filter using sinusoidal current control strategy with three-phase unbalanced nonlinear, inductive load condition for aircraft power utility

D. Performance of APF under combined all three loads connected at different time interval

From the simulation results shown in figure 7, it has been observed that that the THD of source current & source voltage was 2.72% and 1.65% respectively. The response time for compensation was 0.01 sec.

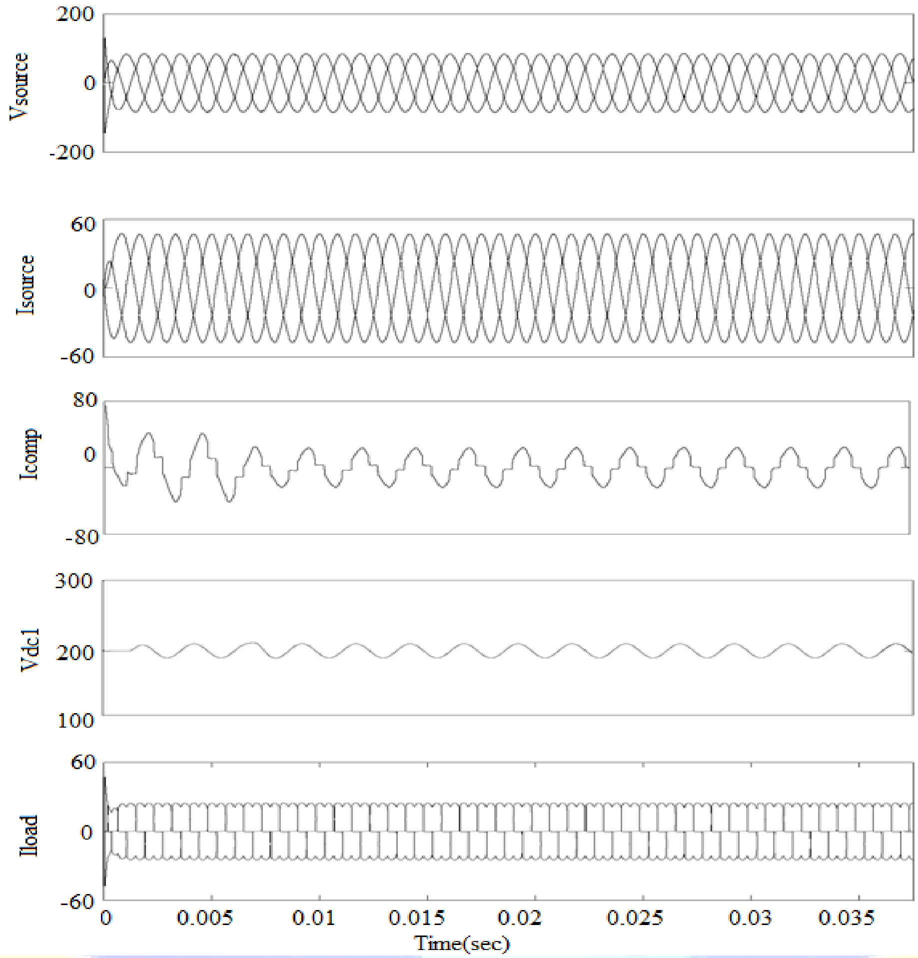

Figure 7 Source Voltage, source current, compensation current (phase b), DC link Voltage and load current waveforms of Active power filter using sinusoidal current control strategy with all three loads connected for aircraft power utility

E. Analysis of the Simulation Results

Simulation results of uncompensated system and compensated system have been tabulated in Table 1 and Table 2 and from there; we can easily say that all the results are within the limits of international standard.

TABLE 1

THDs & RESPONSE TIME OF UNCOMPENSATED SYSTEM

Loads connected	THD-I (%)	THD-V (%)
With Load 1	4.03	30
With Load 2	2.07	28.96
With Load 3	1.2	5.45
All three loads connected	9.5	1.55

.TABLE 2

SUMMARY OF SIMULATION RESULTS USING APF

Strategy& load details	THD-I (%)	THD-V (%)	Response Time(sec)
Load 1	2.43	1.44	0.0074
Load 2	2.30	1.29	0.0085
Load 3	0.44	0.32	0.0074
All three loads at different time interval	2.72	1.65	0.01

IV. Conclusion

This paper has presented a study of control strategy for shunt active filter installed in aircraft power utility of 400 HZ. This has been observed that the strategy is well capable of reducing voltage and currents THDs within very short time.

VII. APPENDIX

The system parameters used are as follows [1]:

Three-phase source voltage: 110V/400 Hz

Filter inductor=0.25m H

Filter capacitor: 5 uF,

Dc voltage reference: 400 V

Dc capacitor: 4700uF

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