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A Novel Series Active Power Filter Scheme using Adaptive Tabu search Algorithm for Harmonic Compensation

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ABSTRACT

A novel series active power filter to eliminate harmonics and compensate reactive power is presented and analyzed. The proposed active compensation technique is based in a series active filter using adaptive tabu search algorithm in the conventional Sinusoidal Fryze voltage control technique. The paper analyzes the proposed series active power filter when connected with load of three-phase rectifier series with inductive load and a pure resistance directly. Simulation results obtained using MATLAB/Simulink confirm the viability of the proposed compensation technique.

Keywords: series filter, reactive power compensation, adaptive tabu search algorithm, MATLAB.

1. INTRODUCTION

Compensation methods based in active and passive filters to remove current harmonics and to compensate reactive power have already been presented and published in the technical literature [1, 2, 3]. Shunt, series and hybrid active filter topologies have been conferred and demonstrated to be a feasible alternative for industrial compensation [5], [7]. Although passive filters LC are most frequently used to compensate current harmonics, it is well recognized that they are not the most excellent solution, since they generate resonance problems, affect voltage regulation, and produce high inrush currents. Shunt active filter is a better option for current harmonic and reactive power compensation; however its application in high power load compensation is still limited due to power semiconductors restrictions [2].

The traditional shunt active power filter works as a current controlled source while the series active approach acts as a voltage controlled source. The series approach compensates for voltage distortion, unbalances, and regulation (sags and swells) [4]. Other well known topology is the hybrid filter [1], [7], [9], which employs a combination of active and passive filters, and is a good and successful alternative for current harmonics compensation. Now days, advance soft computing techniques are used widely in automatic control system or for optimization of the system applied. Some of them are such as adaptive tabu search [10]-[14], optimization of active power filter using Genetic algorithm[15]-[18], power loss minimization using particle swarm optimization[19], neural network control [20]-[24] applied in both machinery and filter devices.

This paper presents an active compensation scheme which has been optimized using Adaptive tabu search algorithm implemented with a series active power filter, and is designed to compensate line current harmonics and reactive power generated by static converters.

The paper has been organized in the following manner. The APF configuration and the load under consideration are discussed in Section II. The control algorithm for APF is discussed in Section III. Optimization using adaptive tabu search has been presented in Section IV. Comparative evaluation using MATLAB/ Simulink results are discussed in Section V and finally Section VI concludes the paper.

2. SYSTEM DESCRIPTION

As shown in Figure 1, Series Power filter improves the power quality and compensates the harmonics in the system. The series active filter ideally behaves as a controlled voltage source in such a way that the load voltage will have only positive-sequence at the fundamental frequency component.

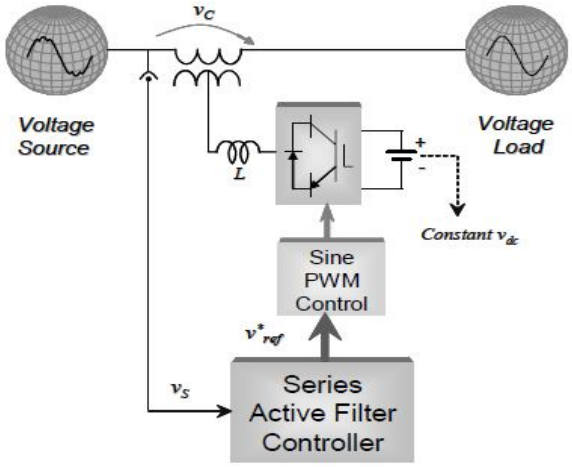

Figure 1 Series Active Power filter

3. CONTROL THEORY

The series active filter controller generates the reference voltage v^*_{ref} that will be synthesized by the PWM converter and positioned in series with the supply voltage, to force the load voltage, v_L, to become sinusoidal and balanced.
Based on Sinusoidal Fryze Voltages Control Strategy, the series active filter controller, as shown in Fig. 2, is composed by a circuit that senses the fundamental positive sequence component of the system voltage and produce compensating voltage references by performing the distinction between that fundamental component and the measured system voltages.

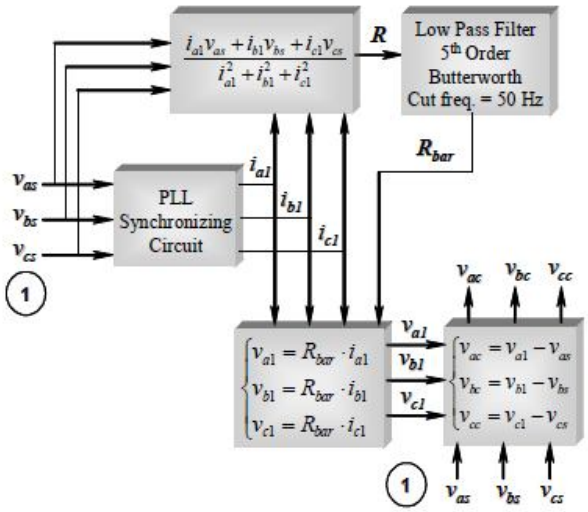

Figure 2. Sinusoidal Fryze Voltages Control Strategy

4. OPTIMIZATION USING ADAPTIVE TABU SEARCH ALGORITHM

Adaptive Tabu Search (ATS) is a modified version of original tabu search formula for combinational optimization problem suggested by Glover. This method is very effective for solving non-linear continuous optimization problems. The modification which has been added into the new version is discretized continuous search space, back-tracking and adaptive radius.
The proposed ATS method searches the optimum value of the proportional integral controller parameters i.e. K_p and K_I and the objective function is decided such as to give their optimum value with the conditions of minimum overshoot, rise time and settling time. Boundary of Kp and Ki, their upper limits and lower limits, then radius value, conditions for ATS back tracking, objective function and stop criteria has been defined. Maximum Searching iteration (500 rounds) for ATS has been set as stop criterion. Figure 3 shows the flow chart for search of parameters using adaptive tabu search method.

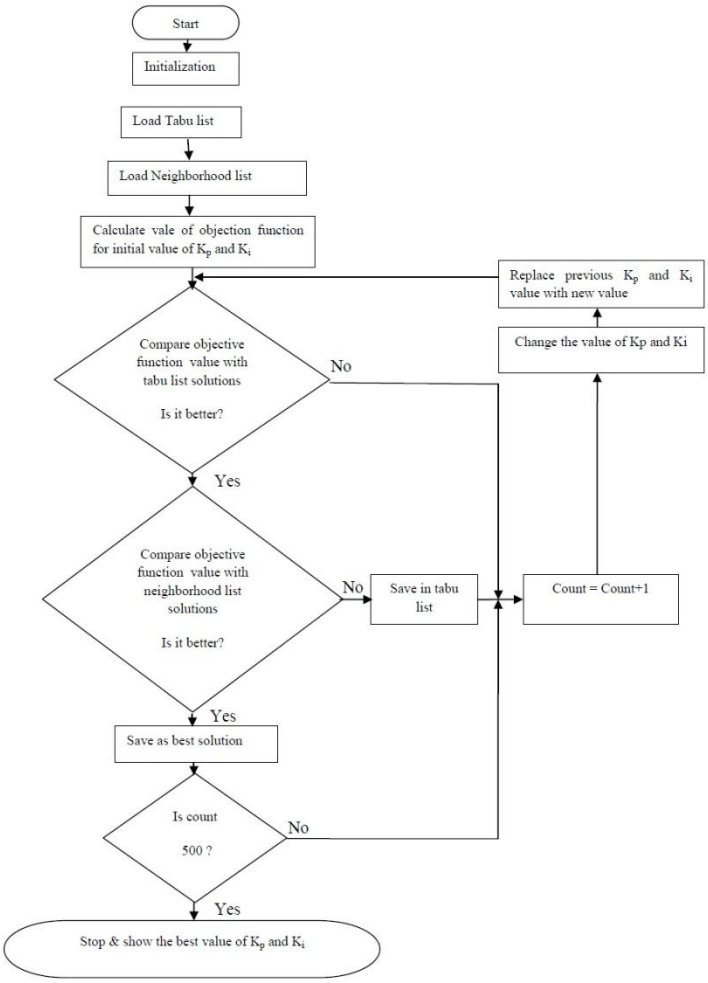

Figure 3. Flow chart for search of parameters using ATS

5. COMPARATIVE EVALUATION USING SIMULATION RESULTS

The proposed scheme of Series Power filter (SPF) is simulated in MATLAB environment to estimate its performance. The load consists of three-phase rectifier series with inductive load and a pure resistance directly. The proposed control scheme has been simulated to compute the performance of SPF and analysis through THD of source and load voltage. The simulation results clearly demonstrate that the scheme is able to successfully reduce the significant amount of THD in source voltage within limits of IEEE 519-1992. Simulation results have been analyzed on the basis of THD obtained. Simulation has been done for 15 cycles. Comparative evaluation of simulation using SFV technique and optimized SFV by ATS algorithm has been done.

a. Uncompensated system

After doing simulation in MATLAB/Simulink without using any filter (Figure 4) i.e. for *Uncompensated System*, it has been observed that the THD of source voltage found when load is connected with the system is 31.6%. By observing these data, we can easily understand supply has been polluted when load has been connected.

b. Performance of APF

During the analysis of simulation results based on THD, this has been observed (Figure 4) that while doing simulation of Series power filter based on Sinusoidal Fryze Voltages Control Strategy that the THD of source Voltage were 2.34%; whereas when model has been optimized using ATS algorithm has been used, it has been observed that the THD of source voltage reduces to 1.63% which is absolutely the improvement from conventional one.

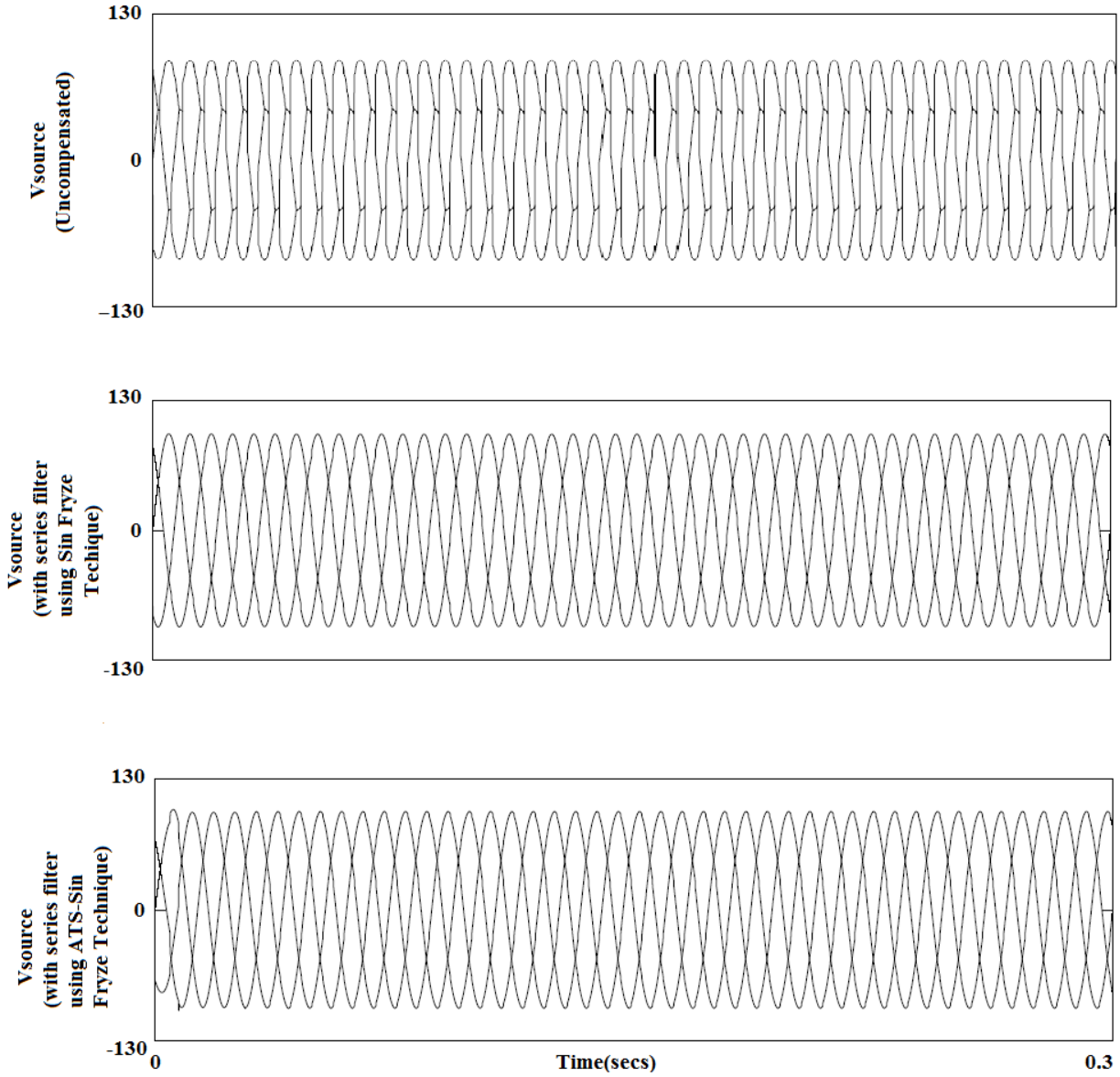

Figure 4 source voltage waveforms of uncompensated system, using series filter utilizing Sin Fryze voltage technique and using series filter utilizing ATS-Sin Fryze voltage technique

6. CONCLUSION

A novel ATS-Sin Fryze control technique for series active filter has been reported which clearly demonstrates its compensation ability. This also has been observed that adaptive tabu search algorithm has well optimized the model and increased the ability of conventional Sinusoidal Fryze Control model. From the simulation results, this can be easily seen that the proposed novel active filter is effective better than the traditional one.

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