Application of Adaptive Tabu Search Algorithm in Sinusoidal Fryze Voltage Control based Hybrid Series Active Power Filter

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ABSTRACT

A novel hybrid series active power filter to eliminate harmonics and compensate reactive power is presented and analyzed. The proposed active compensation technique is based in a hybrid series active filter using adaptive Tabu search (ATS) algorithm in the conventional Sinusoidal Fryze voltage (SFV) control technique. Optimization of the conventional Sinusoidal Fryze voltage control technique has been done using adaptive tabu search algorithm. This paper discusses about the comparative performances of conventional Sinusoidal Fryze voltage control strategy and ATS-optimized controllers. ATS algorithm has been used to obtain the optimum value of $K_p$ and $K_i$. Analysis of the hybrid series active power filter system under non linear load condition and its impact on the performance of the controllers is evaluated. Effectiveness of the hybrid series active power filter to provide harmonic damping is demonstrated by MATLAB/Simulink results. Total harmonic distortion (THD) demonstrates the practical viability of the controller for hybrid series active power filter to provide harmonic isolation of non-linear loads and to comply with IEEE 519 recommended harmonic standards.

Keywords: Adaptive Tabu Search Algorithm (ATS), Harmonics, Hybrid Power Filter, IEEE 519, Series Active Filter, Sinusoidal Fryze Voltage Control, Passive Filter

1. INTRODUCTION

Over the years, there has been an incessant proliferation of nonlinear type of loads due to the rigorous use of power electronic control in all branches of industry as well as by the common consumers of electric energy (Aredes, 1991; Moran, 1995; Maniya, 2013; Ruminot, 2006). This solid state control of ac power using thyristors and other semiconductor switches is extensively used to feed controlled electric power to electrical loads, for example adjustable speed drives (ASD’s) furnaces, computer power supplies, etc. Such controllers are also
employed in HVDC systems and renewable electrical power generation (Vijay, 1996). These days, the power electronic converters are able of processing huge amount of power, and due to their advantages such as improved efficiency and ease of control, have caused a spectacular increase in the number of power electronic loads in the industry/system. Unfortunately, power electronic loads have an intrinsically nonlinear nature, and they therefore draw a distorted current from the mains supply. Specifically, they draw non-sinusoidal current, which is not in proportion to the sinusoidal voltage. Consequently, the utility supplying these loads has to offer large reactive volt-amperes. Also the harmonics produced by the load pollutes it. As nonlinear loads, these solid-state converters draw harmonic and reactive power part of current from ac mains.

Problem, which has been seen while using nonlinear loads, is injected harmonics, reactive power burden, unbalance and excessive neutral current. Due to them, in addition to poor power factor, system’s efficiency has also been reduced drastically. They also cause disturbance to other consumers and interference in nearby communication networks, excessive heating in transmission and distribution equipment, errors in metering and malfunctioning of utility relays. The inflictable tariffs levied by utilities against excessive VARs and the threat of stricter harmonics standards have led to extensive surveys to quantify the problems associated with electric power networks having nonlinear loads, i.e. the load compensation techniques for power quality improvement.

To remove these problems, passive filters has been formulated, but they are generally designed to compensate selected harmonic components so some harmonics are always there. The passive filter not only affects inverter harmonic injection but forces on the harmonics created by a joined non-linear load. There are numerous techniques for controlling harmonic current flow, for example DC ripple injection, harmonic current injection, series and parallel active filter systems, magnetic flux compensation. Passive harmonic filters are frequently employed to decrease current distortion and voltage harmonics in distributed generation systems.

The shunt passive filters expose lower impedance at tuned harmonic frequency than the source impedance, so that reduced harmonic currents flow into the source (Rubén, 2005). However, the filtering characteristics of shunt passive filter are decided by the impedance ratio of the source and the shunt passive filter. However, in practical application these passive second order filters show the following disadvantages:

- The source impedance powerfully affects filtering characteristics;
- Since both the harmonic and the fundamental current components flow into the filter, the capacity of the filter must be rated by taking into account both currents;
- When the harmonic current components increase, the filter can be overloaded;
- Parallel resonance between the passive filter and the power system causes amplification of harmonic currents on the source side at a specific frequency;
- The passive filter may be fall into series resonance with the power system, so that voltage distortion produces excessive harmonic currents flowing into the passive filter.

Compensation methods based in active and passive filters to remove current harmonics, voltage harmonics and to compensate reactive power have already been presented. Shunt, series and hybrid active filter topologies have been conferred and demonstrated to be a feasible alternative for industrial compensation. 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
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